JOURNAL OF THE AMERICAN CERAMIC SOCIETY

A · MONTHLY · JOURNAL · DEVOTED · TO · THE · ARTS · AND · SCIENCES
RELATED · TO · THE · SILICATE · INDUSTRIES

ABSTRACTS
VOL. 13 NO. 5

VOLUME 17 MAY · 1934 NUMBER 5

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The Journal of the American Ceramic Society

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Publication Office: 20th & Northampton Sts., Easton, Pa.
Editorial and Advertising Offices: 2525 N. High St., Columbus, Ohio.
Executive Office: 2525 N. High St., Columbus, Ohio.
Committee on Publications: L. NAVIAS, *Chairman;* L. J. TROSTEL, M. F. BEECHER, R. M. KING, ROSS C. PURDY.
Entered as second-class matter at the post office at Easton, Pa., under the Act of March 3, 1879.
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Subscription twelve dollars a year. Single numbers one dollar
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  Recluses, without communication with other minds, make no advancement and no contribution.
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  Those who share in the benefits and not in the costs of a federation are not wise, for the benefits to be derived are proportionate to the means made available to the federation.
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The American Ceramic Society

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RELATION BETWEEN UNCOMBINED QUARTZ AND THERMAL EXPANSION OF CERAMIC BODIES*

By W. R. Morgan

ABSTRACT

The percentage by volume of uncombined quartz in each of fifteen commercial shale and fireclay bodies was determined by the intercept method by means of a petrographic microscope and a Wentworth screw-micrometer.

The thermal expansion of the same bodies fired commercially was determined from atmospheric temperature to 1000°C by measurement of the expansion as indicated by a $^1/_{10,000}$-inch Ames dial when the 9-inch specimen was heated in an electric resistance furnace.

Photomicrographs of two bodies are given, showing the grain size and distribution of the quartz; expansion curves are also given, showing high cristobalite expansion for the body containing a low percentage of uncombined quartz, and low cristobalite expansion for the body containing a high percentage of uncombined quartz.

Cristobalite began to form by dissociation of the clay minerals at about cone 5 (approximately 1200°C). For bodies fired from cones 5 to 7, the expansion at 260°C, indicating the presence or absence of cristobalite, was inversely proportional to the percentage of uncombined quartz in the body. The expansion from 565 to 620°C was directly proportional to the percentage of uncombined quartz in the body.

I. Introduction

Inflections in the expansion curves of clay bodies at temperatures corresponding approximately to high-low inversion temperatures of cristobalite (200 to 275°C) and quartz (573°C) are customarily attributed to the presence of these substances.[1] Tridymite may also be expected to have such an effect at its inversion temperatures (117°C and 163°C) but the inflection is of a lower order of magnitude and less definite than those associated with cristobalite and quartz.

The temperature conditions under which the various modifications of silica are formed from each other and under which they are stable have been thoroughly discussed by Sosman[2] and are now well established. An additional source of cristobalite in clays, other than inversion of quartz initially present as such, was established by McVay and Thompson[1a] in their study of the effect of heat on china clays by X-ray methods. They found that cristobalite was present in washed Georgia kaolin when fired to 1225°C and above, and was present in small amounts in A-1 English china clay when fired to 1250°C and 1275°C. The inflection in the expansion curves at approximately 200°C was attributed to the cristobalite which was formed by the dissociation of the kaolinite molecule and not from quartz originally present in the clay. The inflection due to cristobalite disappeared in the English china clay because of solution of the cristobalite promoted by the higher flux content of the English china clay. The inflection in the expansion curve due to cristobalite in the purer Georgia kaolin was made to disappear by the addition of fluxes.

This possible source of cristobalite was also suggested by Westman[1b] shortly after the work of McVay and Thompson was submitted for publication.

The results obtained by McVay and Thompson were later verified by Heindl, Pendergast, and Mong.[1e]

The formation of cristobalite by dissociation of the clay minerals then seems to be definitely established and it may, therefore, be expected that under proper firing conditions cristobalite will be formed irrespective of the presence of uncombined silica in a body. Fenner's work, reviewed by Sosman,[2] indicated that very little inversion of quartz to cristobalite occurred at 1250°C and that the inversion was only about two-thirds complete after ninety hours at 1360°C. Apparently cristobalite forms more readily by dissociation of clay minerals than by inversion from quartz so that for a large group of commercial products cristobalite may be expected to

* Presented at the Annual Meeting, American Ceramic Society, Cincinnati, Ohio, February, 1934 (Refractories Division). Received December 16, 1933.

[1] (*a*) T. N. McVay and C. L. Thompson, "Effect of Heat on China Clays," *Jour. Amer. Ceram. Soc.*, **11** [11], 829–41 (1928).

(*b*) A. E. R. Westman, "The Thermal Expansion of Fireclay Brick," *Univ. of Ill. Eng. Expt. Station Bull.*, No. 181, 1928.

(*c*) R. A. Heindl and W. L. Pendergast, "Progress Report on Investigation of Fireclay Brick and Clays Used in Their Preparation," *Jour. Amer. Ceram. Soc.*, **12** [10], 640–75 (1929).

(*d*) R. A. Heindl and W. L. Pendergast, "Fireclays: Some Fundamental Properties at Several Temperatures," *ibid.*, **13** [10], 725–50 (1930).

(*e*) R. A. Heindl, W. L. Pendergast, and L. E. Mong, "Kaolins; Effect of Firing Temperatures on Some of Their Physical Properties," *Bur. Stand. Jour. Research*, **8**, 199–215 (1932).

[2] R. B. Sosman, Properties of Silica. Chemical Catalog Co., 1927.

form by dissociation of clay minerals in sufficiently large amounts to affect the expansion of the bodies noticeably. While it is possible that some tridymite may be formed, it is not probable that the amount will be large and, furthermore, the effect on expansion would be small compared to that of cristobalite both because of the small amount of tridymite present and because of its low expansion.

The two forms of silica, then, which may be expected to have the greatest effect on the expansion of clay bodies fired at temperatures below which quartz inverts rapidly to cristobalite are quartz, initially present in the body, and cristobalite, formed by the dissociation of the clay minerals.

II. Purpose of the Present Study

The study of the effect of the various forms of silica on the expansion characteristics of clays has previously been confined to relatively pure materials. It is the purpose of the present study to investigate the effect of the various forms of silica on the expansion of less pure clays, such as shales and low-grade fire clays used in the manufacture of heavy clay products. Such information should be of value in firing, cooling, and, in some cases, in the use of the product.

III. Scope of the Work

The fifteen bodies studied were supplied by fifteen companies located in nine different states and are typical of the shale and low-grade fire-clay bodies used in the manufacture of heavy clay products.

The experimental work was confined to the determination of the relation between expansions of the bodies and the percentages of uncombined quartz which they contained.

IV. Forms of Silica and Relation to Expansion

The properties of silica in its various forms are so well known that it will be sufficient for the present purpose to recall that the forms of silica of primary importance are quartz, tridymite, and cristobalite and their high-low modifications. Each form has a characteristic expansion, a part of which is the sudden expansion at the high-low inversion temperatures which are as follows: low quartz to high quartz, 573°C; low tridymite to high tridymite, 117 to 163°C; and low cristobalite to high cristobalite, 200 to 275°C.

Expansion curves according to Le Chatelier[2] are given in Fig. 1 for quartz, tridymite, and cristobalite.

Theoretically, the expansion of a body near the inversion temperature of quartz (573°C) should be approximately proportional to the percentage of uncombined quartz in the body, other factors

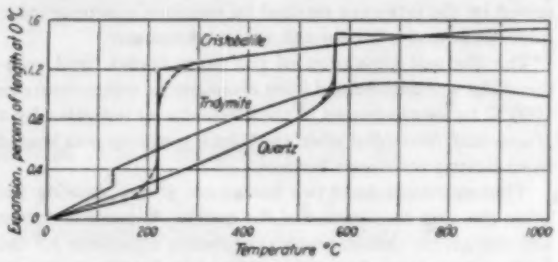

FIG. 1.—LeChatelier's curves.

being equal. Furthermore, since cristobalite is formed by dissociation of the clay minerals, it would be expected that when clay bodies are fired to temperatures below which quartz inverts rapidly to cristobalite, expansion due to cristobalite formed, therefore, by dissociation of clay minerals would be related to the amount of clay minerals in the body or would be inversely proportional (in a sense) to the amount of uncombined quartz, since the latter may be considered to be the chief "impurity."

V. Procedure

The thermal expansion of each body was determined by means of thermal-expansion equipment devised by Westman.[1b] Essentially, the apparatus consisted of an electric furnace controlled by a rheostat and wattmeter in which the specimen of fired clay was mounted in a vertical position between two end-pieces. The lower end-piece rested on a water-cooled frame while the upper end-piece rested on the upper end of the specimen. An Ames dial, graduated in ten-thousandths of an inch, was clamped to the water-cooled frame above the upper end-piece with the spindle in contact with the end-piece.

The bottom end-piece and the dial were kept in fixed positions by the water-cooled frame, and any movement of the dial indicated the expansion or contraction of the specimen and end-pieces. Since the expansion of the end-pieces was known, the expansion of the sample was obtained simply

[2] H. Le Chatelier, La Silice et les Silicates. A. Hermann & Fils, Paris, 1914.

by subtracting the expansion of the end-pieces at each temperature from the total expansion indicated by the dial reading.

The temperature of the specimen was determined by means of three thermocouples attached directly to it.

The expansions were determined through the range from atmospheric temperature to 1000°C (1810°F).

VI. Per Cent Uncombined Quartz

In conjunction with the thermal expansion tests, thin sections (0.03 mm.) of each body were made and the per cent of uncombined quartz was determined by the intercept method with a petrographic microscope and a Wentworth screw-micrometer. In addition, photomicrographs

TABLE I

Body No.	Uncombined quartz (%)	Probable error	Number of traverses	Per Cent Expansion 200°C (500°F)	566–621°C (1050–1150°F)	1000°C (1810°F)	Fired to cone
6	26.7	±0.5	6	0.110	0.090	0.550	3
9	25.5	±0.3	8	0.070	0.090	0.440	06
12	26.6	0.2	6	0.125	0.100	0.560	01
13	12.3	0.5	9	0.115	0.045	0.480	04
17	12.4	0.4	10	0.095	0.070	0.510	02
18	5.1	0.3	6	0.250	0.045	0.660	5
20	7.1	0.4	6	0.265	0.060	0.670	7
21	14.0	0.3	6	0.130	0.095	0.570	4
27	12.6	0.1	6	0.110	0.080	0.520	3
32	7.6	0.1	8	0.130	0.055	0.570	3–4
33	14.5	0.2	6	0.245	0.075	0.670	4
37	9.6	0.8	12	0.170	0.075	0.610	6
41	15.3	0.3	9	0.070	0.070	0.430	4
42	33.0	0.4	10	0.140	0.085	0.540	5
72	15.8	0.6	6	0.115	0.050	0.530	5

(magnification 82 diameters) of each body were made for a comparison of the size and distribution of quartz grains.

VII. Accuracy of Measurements

The 9-inch expansion specimens were measured to 0.01 inch or about 0.1%. The Ames dial was accurate to about ± 2 divisions or an accuracy in the measurement of expansion at 1000°C of from 2 to 5%, depending on the expansion of the specimen.

In the determination of uncombined quartz, a sufficient number of traverses was made to reduce the probable error of the mean to less than 1%. The probable error varied then from 1 to 4% and ran as high as 10% in a few cases in which the per cent of uncombined quartz was exceptionally low.

Temperature measurements were read to about 1°C and the heating schedule for the furnace was such that the temperatures of the three couples did not differ by more than 10°C.

VIII. Results

The results of the thermal expansion and uncombined quartz determinations are given in

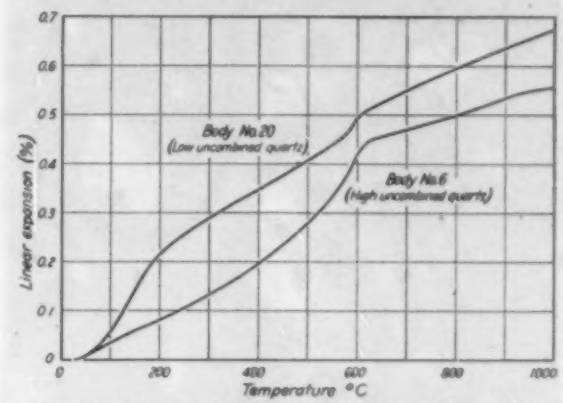

FIG. 2.—Thermal expansion of bodies containing high and low percentages of uncombined quartz.

Table I. The total expansion at 1000°C varied from 0.43 to 0.67% with an average, for all bodies tested, of 0.554%. A typical expansion curve

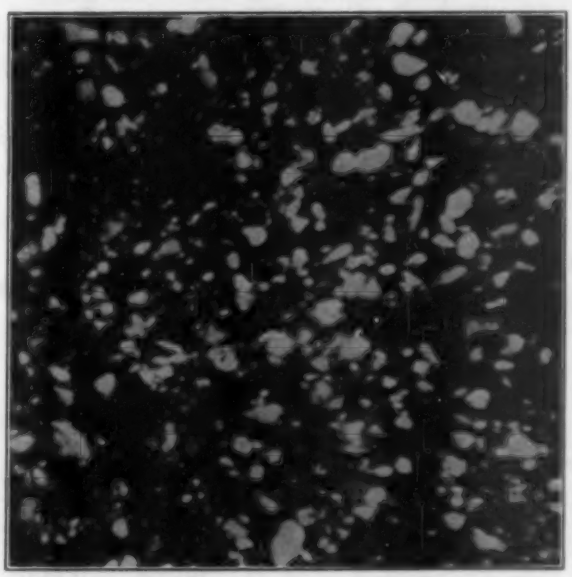

FIG. 3.—Body No. 6 (× 82 diam.). High uncombined quartz, low cristobalite expansion.

for a high quartz body showing slight cristobalite expansion, and a typical curve for a low quartz body showing high cristobalite expansion are given in Fig. 2. Photomicrographs of the two

bodies are shown in Figs. 3 and 3*a* for a comparison of the size and distribution of quartz grains.

The firing temperatures for all bodies tested vary from cones 06 to 7.

When expansion at 260°C (500°F) is plotted against firing temperature (Fig. 4), it is evident

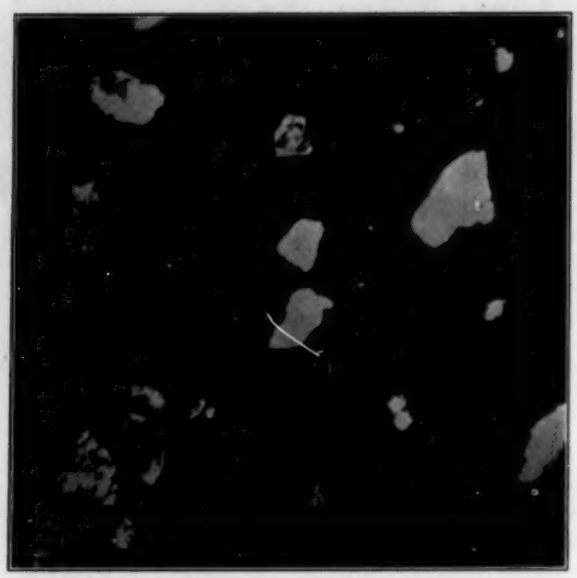

FIG. 3*a*.—Body No. 20 (× 82 diam.). Low uncombined quartz, high cristobalite expansion.

that firing temperature does not begin to increase the expansion by formation of cristobalite until about cone 5 (1205°C) is reached.

Examination under the microscope failed to show any evidence of inversion of the quartz grains to cristobalite.

Therefore, when the expansion at 260°C (500°F) of the bodies fired to cone 5 and above is plotted against the reciprocal of the percentage of uncombined quartz in the body (Fig. 5), an approximately linear relationship is obtained, indicating that when bodies are fired at a temperature high enough to dissociate the clay minerals and form cristobalite, the expansion at 260°C (500°F) is inversely proportional to the percentage of uncombined quartz in the body.

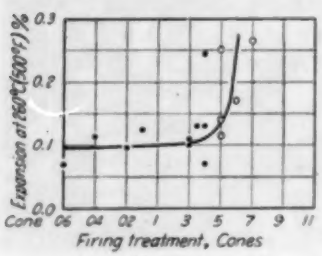

FIG. 4

This is also shown in Fig. 6 in which per cent uncombined quartz is plotted against expansion at 260°C (500°F). An average curve for the bodies fired at cone 5 and above is shown and it will be noted that the expansions of nearly all other bodies lie below the curve, *i.e.*, the expansions for bodies fired below cone 5 are less than for those fired at cone 5 and above.

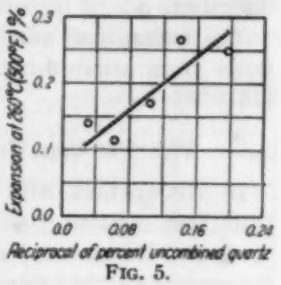

FIG. 5.

In Fig. 7 the expansion between 565°C and 620°C (1050°F and 1150°F) is plotted against the percentage of uncombined quartz, showing that expansion in this temperature range increases as the percentage of uncombined quartz increases as would be expected.

IX. Summary and Conclusions

Thermal expansion, at 260°C, of the bodies studied is practically independent of firing temperature from cones 06 to 5, increasing slightly but remaining almost constant at 0.1%.

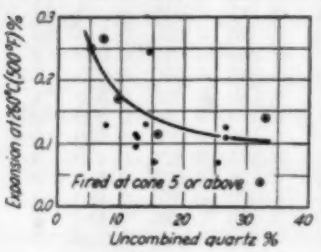

FIG. 6.

Examination under the microscope failed to show any evidence of inversion of the quartz grains to cristobalite. Nevertheless at about cone 5 cristobalite begins to be formed, presumably by dissociation of clay minerals; thus the expansion, at 260°C, of a body fired at a given temperature at or above cone 5, but below temperatures at which quartz inverts readily to cristobalite (probably cones 10 to 12) may be expected to be inversely proportional to the percentage of uncombined quartz in the body.

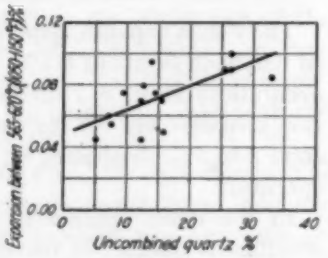

FIG. 7.

Therefore, bodies fired above cone 5, but below temperatures at which quartz inverts rapidly to

cristobalite (probably cones 10 to 12), may be expected to become more difficult to cool in the region of cristobalite inversion, 200 to 275°C (392 to 527°F), as the percentage of uncombined quartz in the body decreases.

The expansion between 565°C and 620°C (1050°F and 1150°F) is roughly directly proportional to the percentage of uncombined quartz in the body.

Therefore, bodies of the types studied may be expected to become more difficult to fire and cool in the region of the quartz inversion, 573°C (1063°F), as the percentage of uncombined quartz in the body increases.

It seems probable that, since cristobalite expansion has been reported to have been eliminated in kaolins[16] by introduction of fluxes, the cristobalite expansion of impure shales and fire clays would disappear if sufficiently high-firing temperatures could be employed, without overfiring, to cause the cristobalite to dissolve in the comparatively high flux shale and fireclay bodies.

Acknowledgment The data presented in this paper were obtained in an investigation which was conducted by the Engineering Experiment Station of the University of Illinois, of which M. S. Ketchum, then Dean of the College of Engineering, was Director, and of which A. C. Willard, Acting Dean of the College of Engineering, is Director at the present time. The work was done, in coöperation with the Clay Products Association, in the Department of Ceramic Engineering of which C. W. Parmelee, Professor of Ceramic Engineering, is the head.

Acknowledgment is made to Professor Parmelee for his interest and advice and for his critical examination of the material submitted for publication.

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APPLICATION OF STOKES' LAW IN THE DETERMINATION OF THE ABSOLUTE VISCOSITY OF GLASS*

BY R. G. HUNTER

ABSTRACT

Stokes' law, with a modified form of Ladenburg's wall-correction factor, has been applied to determine the viscosity of glass from the velocity of a freely falling platinum sphere. The apparatus is described in full, a special feature being the radio equipment used to measure the velocity of the falling sphere.

Reproducibility of results is excellent and good agreement has been obtained using spheres of different diameters, vindicating the use of the revised wall-correction factor. Results on a few typical glasses are discussed.

I. Choice of Method

The falling sphere method was chosen mainly because it is based on one of the fundamental laws of physics. It was realized, of course, that this method to date does not enjoy a very high reputation. This, however, is perhaps due more to lack of refinements in the equipment than to defects in the method.

II. Previous Attempts to Use the Stokes' Method

Arndt,[1] Staley,[2] and Doelter[3] were among the early investigators who applied Stokes' law in measuring the viscosity of glass. Their methods were similar in that they suspended cylindrical or spherical platinum bodies in the molten glass by means of a wire attached to a pointer. The rate at which the body fell was shown upon a scale.

Stott, Turner, and Sloman[4] and others used a method in which a counterbalanced platinum sphere was allowed to fall at different velocities through the glass.

The above methods were investigated when this equipment was first built and were found to be subject to disadvantages, among which were (*a*) effect of surface tension on the wire supporting the platinum sphere; (*b*) variable amount of glass clinging to the wire; (*c*) results not accurately reproducible; and (*d*) some doubt whether results were in absolute viscosity units.

In 1921 Masson, Gilbert, and Buckley[5] suggested the use of a freely falling platinum sphere,

* Presented at the Annual Meeting, AMERICAN CERAMIC SOCIETY, Cincinnati, Ohio, February, 1934 (Glass Division). Received February 15, 1934.

[1] K. Arndt, "Die Messung der Zahigkeit," *Z. Chem. Apparatenkunde*, **3**, 549 (1908).

[2] H. F. Staley, "Viscosity of Borate Glasses," Orig. Comm., *8th Internat. Cong. Appl. Chem.*, Vol. 5, p. 127, 1912.

[3] C. Doelter, "Über die Viskosität der Silikatschmelgen," *Chem.-Ztg.*, **36**, 36 (1912).

[4] V. H. Stott, D. Turner, and H. A. Sloman, "Counterbalanced Sphere," *Proc. Roy. Soc.*, **A108**, 154–71 (1925).

[5] I. Masson, L. F. Gilbert, and H. Buckley, *Jour. Soc. Glass Tech.*, **5**, 337 (1921).

the velocity to be measured by X-rays. Lazarev,[6] Wood,[7] and others[8] have used this method with success.

The outstanding difficulty, of course, is to obtain satisfactory photographs due to the absorption of the rays by a properly insulated furnace.

The only logical alternative was to so design the equipment that the sphere in falling would give a signal at the moment of transit past each of two points or regions, at a known distance apart. This was carried out by means of a special radio hook-up which will be described later.

III. Theoretical Considerations

The modified form of Stokes' law, derived in 1907 by Ladenburg,[9] is given by the following equation:

$$\eta = \frac{2}{9}\frac{gR^2\ (d_1 - d_2)}{V}\ \frac{1}{\left(1 + 2.4\frac{R}{r}\right)\left(1 + 3.3\frac{R}{h}\right)} \quad (1)$$

η = viscosity of liquid in absolute units
g = acceleration due to gravity
R = radius of falling sphere (cm.)
d_1 = density of falling sphere
d_2 = density of liquid
V = velocity of falling sphere (cm./sec.)
r = radius of crucible (cm.)
h = height of liquid in crucible (cm.)

The above equation holds for a small sphere falling with a uniform velocity in a medium of finite dimensions. The factors $\left(1 + 2.4\frac{R}{r}\right)$ and $\left(1 + 3.3\frac{R}{h}\right)$ or fw and fh are boundary corrections to compensate for the effect of the crucible walls and the height of the liquid, respectively, on the velocity of the sphere. The corrections, as determined by Ladenburg, were tested for values of $\frac{R}{r} < 0.09$, $\frac{R}{h} < 0.008$. The latter ratio will usually be small regardless of experimental conditions, but when working with molten glass where there is a combination of high viscosities and high temperatures, it becomes impractical to work within the range of values of R/r as defined by Ladenburg. In consequence the question arose at the outset of this work whether Ladenburg's wall-correction factor, fw, could be applied for ratios of $R/r = 0.33$.

In 1931, when this equipment was under construction, Francis[10] investigated the Ladenburg correction factor and found that it did not hold for values of R/r greater than 0.1.

It is obvious that when R approaches r, fw should approach infinity, whereas the limiting value of Ladenburg's correction is 3.4.

The observations were carried out using glycerol, with a viscosity of four poises, and glucose, with a viscosity of 700 poises. Steel balls were used with values of R/r varying from 0.01 to 0.9. The values of the wall factor were computed for each ball and found to agree well with the general expression

$$fw = \left(\frac{1}{(1 - R/r)}\right)^{2.35}$$

for both glucose and glycerol and for values of $R/r = 0.35$. This is also in excellent agreement with Ladenburg's work for values of $R/r < 0.1$.

Thus the revised form of Ladenburg's formula is

$$\eta = \frac{2}{9}\frac{gR^2\ (d_1 - d_2)}{V} \cdot \frac{(1 - R/r)^{2.35}}{(1 + 3.3\ R/h)}.$$

The wall correction has been further checked in molten glass for a range of R/r, from 0.15 to 0.35, and the results were in excellent agreement.

In using the formula for computing results, corrections must be made for the expansion of the platinum spheres and crucible and the change in density of the platinum and glass, etc. There is little information available concerning the density of molten glass with the exception of the work of Li[11] and Hanlein.[12] However, with the information available and with what practical information there is concerning the total expansion of glass from room to furnace temperatures, the changes in density have been computed with quite sufficient accuracy. The fact that it is the difference in density that is used in the equation facilitates matters since the density of the sphere is much greater than that of glass.

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[6] P. Lazarev, *Chim. Ind.* [Special No.], pp. 441–43 (April, 1928); *Keram. i Steklo*, No. 7, 1928; X-ray method suggested by M. G. Buckley.

[7] A. R. Wood, *Jour. Soc. Glass Tech.*, **16**, 43–51 (1932).

[8] Deryagin and Khananoc, *Jour. App. Phys.* [Moscow], **5**, 193–99 (1929).

[9] Ladenburg, *Ann. Physik*, **20**, 287; **23**, 447 (1907).

[10] A. W. Francis, *Physics*, **4**, 11 (1933).

[11] S. H. Li, "Densities of Na-Lime-Si Glasses at High Temperatures," Bachelor's Thesis, Univ. of Ill., 1922.

[12] W. Hanlein, *Glastech. Ber.*, **10**, 126 (1932).

IV. Description of Equipment

(1) Principle Figure 1 is a diagrammatic sketch of the apparatus. The glass is contained in a crucible heated uniformly to the desired temperature in the furnace. A ball made of platinum-20% rhodium is heated in a small furnace on top of the large furnace to the same temperature and dropped into the glass. The ball, in falling, passes through two radio coils wound on a sillimanite tube enclosing the crucible. These coils at a known distance apart are part of an oscillating system. As the ball passes through each coil, a signal is excited, picked up by a short-wave receiver, and recorded on an oscillograph, which also records the time to a small fraction of a second. Thus it is possible to measure accurately the velocity of the falling ball and hence the viscosity at any desired temperature.

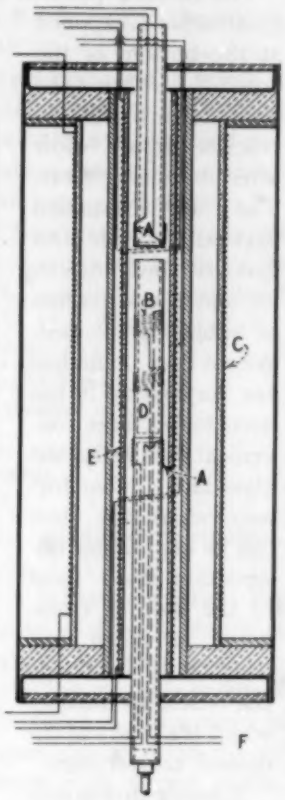

FIG. 1.—Furnace diagram. *A*, platinum wire, 0.02 to 0.1 inch spacing, 20 turns; *B*, radio coils, 65 millimeters center to center, 9 turns each, coils 11 millimeters long; *C*, No. 16 nichrome wire, 1/4-inch spacing; *D*, crucible; *E*, platinum wire, 0.03-inch diameter, spacing varies from 2 millimeters at ends to 5 millimeters at center, winding is divided into 3 coils; *F*, platinum wire, leads to radio coil.

(2) Furnace The furnace consists of an inner Alundum tube, of 2- by 2 3/4-inch diameter and 30 inches in length. On it are wound three coils of platinum-20% rhodium wire, 0.030 inch in diameter. The ends of each coil are led to the top end of the furnace. Separated by an air space is an outer tube of Alundum, 3 3/8 by 4 1/8 inches in diameter and 30 inches in length. To eliminate convection currents in the air space at the top and bottom of the main heating zone are two rings of Alundum cement which completely fill the air space. There is a further Alundum tube, 7 by 7 5/8 inches in diameter and 28 inches in length. This tube has a thread on its outer surface on which is wound a coil of chromel A No. 16 wire, the ends of which are led to the top and bottom of the furnace. The Alundum tubes are cemented on a plate of refractory material, 4 1/4 by 12 inches in diameter and 5/8 inch thick.

The furnace shell is made of aluminum, 12 1/4- by 13 1/4-inches diameter and 33 inches long. The spaces between the second and third tubes and the aluminum shell are filled with pulverized

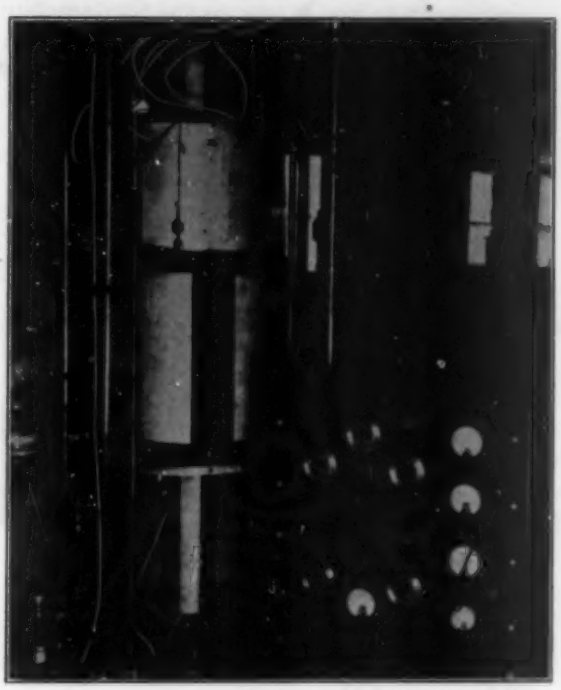

FIG. 2.—Furnace and radio.

Sil-O-Cell and with layers of Sil-O-Cell brick at intervals of one-third the height of the furnace. The entire furnace can be moved up and down by means of ropes, pulleys, and counter-weights which are guided inside the heavy tubes which form the furnace stand of Fig. 2.

Extreme care was taken in the alignment of the individual parts of the furnace to ensure that each Alundum tube was in an exact vertical position and had a common central axis, and that the furnace as a whole moved along a vertical direction. Precautions were also taken that the ball would fall along the central axis of the crucible.

The advantages of this arrangement are that (*a*) the glass is left undisturbed during the entire

heating period; (*b*) the parts connected with the proper melting operation can be adjusted exactly before starting the run; and (*c*) the furnace can be adjusted in such a way that the glass is placed exactly in the zone of uniform temperature.

From the top plate of the furnace stand, a long plug is inserted into the furnace. This plug is made of Alundum tubing, 2 inches in outer diameter, and reaches near the top of the crucible. It contains a tube through which the ball is dropped from the top of the furnace. The inner tube is held in place by Alundum cement.

An adjustable iron holder on the bottom plate of the furnace supports a similar plug which reaches up into the furnace and supports the crucible. This plug contains tubes for a thermocouple and for the two leads to the radio coils which surround the crucible.

FIG. 3.—Control board.

The furnace is heated by a special step transformer, the voltage of which can be changed from 1 to 330 volts. Each coil, of course, is subject to individual control and the current can be varied over a wide range. (Fig. 3.)

(3) Glass Melt The glass is melted in a sillimanite crucible, $1^1/_2$ inches in diameter and 9 inches in height. The crucible is enclosed by a sillimanite tube, $1^3/_4$ inches in diameter and $5^1/_2$ inches in length, on which are wound the radio coils. The tube is prolongated at the top and bottom by two Alundum sleeves, $1^3/_8$ inches in length, which hold it in position.

Thus the ball passes through a certain distance inside the glass and attains a uniform velocity before passing through the radio coils.

The most convenient way to melt the glass is to use glass cylinders molded in such a way that they fit closely into the crucible. These cylinders are made from glass containing the minimum of seed.

The furnace position is adjusted so that the greatest heat is applied at the bottom of the crucible. Thus the glass starts to fill the crucible from below after becoming soft. The air contained between crucible and glass is slowly driven off and the formation of bubbles is avoided. Where the cylinders are very seedy it has been found more convenient to melt the glass in a Globar furnace where the glass can be kept under observation until most of the seed is eliminated, at which time it is transferred into the viscosity furnace which is already at the desired temperature.

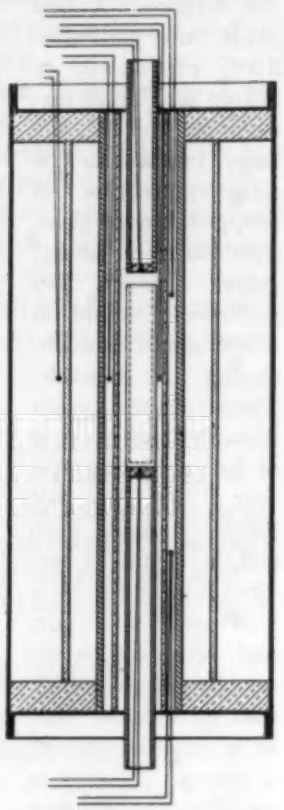

FIG. 4.—Diagram of pyrometer connections.

A motor-driven stirring arrangement is available for use where the glass can only be secured in the form of cullet. A special platinum-20% rhodium stirrer is used with this arrangement.

(4) Platinum Balls The balls used are of platinum-20% rhodium with a diameter of 12 millimeters. There are two additional balls of 6- and 10-millimeter diameter for use at higher temperatures.

(5) Temperature Measurement The maintenance of uniform temperature over the entire height of the melt is secured by means of several platinum-platinum 10% rhodium thermocouples calibrated by means of a Bureau of Standards couple and inserted at the following places: (*a*) the upper platinum heating coil, (*b*) the middle platinum heating coil, (*c*) the lower platinum heating coil, (*d*) the Chromel heating coil, and (*e*) the radio tube, half-

way between the coils corresponding to the center of the melt. (See Fig. 4.)

All thermocouples are connected to a Leeds & Northrup micromax recorder. Thermocouple (*b*) can be connected to a Wilson-Maulen Company controller which acts on the current of the middle heating coil (See Fig. 4).

Thermocouple (*e*), the cold junction of which is maintained at 0°C, is connected to a Leeds & Northrup type "K" potentiometer enclosed in a special housing. The galvanometer is suspended by a Julius suspension to reduce vibration.

(6) Radio Hookup A functional diagram of the equipment is shown in Fig. 5. The equipment is comprised essentially of

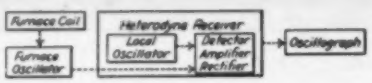

FIG. 5.—Functional diagram of radio equipment.

a high-frequency oscillator, a heterodyne receiver, and an oscillograph.

In the high-frequency or furnace oscillator, the inductance coil of the plate oscillatory circuit is placed in the electric furnace and surrounds the crucible of molten glass. When a ball is dropped into the crucible the oscillator frequency is changed. Since the furnace coil is divided into two sections the frequency shift occurs twice. The rest of the equipment is designed to determine the time elapsed between the two frequency shifts.

The heterodyne receiver is tuned to zero beat with the furnace oscillator.

As the ball approaches the upper half of the furnace coil during its downward path, the gradually increasing change in frequency is apparent when picked up by the receiver as audio frequency. This audio-frequency note can be detected in the ear phones as rising to a maximum when the ball is at the effective center of each coil and then decreasing.

The audio frequency from the receiver is put through a step-down transformer rectified and the direct current output passed into the oscillograph (Fig. 6).

The oscillograph provides means for recording photographically the direct current output due to the audible note and in juxtaposition a timing record which permits the determination of elapsed time to an accuracy of 0.1% for time intervals from one-half second to 40 minutes (Fig. 7). An experienced observer can estimate the time intervals with reasonable accuracy using a stop-watch in connection with the ear phones.

Naturally there are many difficulties associated with the operation of an oscillating circuit at such high temperatures. Chief among these is the alternating current hum, picked up from neighboring circuits; also the fact that with the extremely sensitive tuning required, the slightest

FIG. 6.—Oscillograph.

electrical or mechanical disturbance causes a distortion of the zero beat.

However, by a suitable choice of wire for the radio furnace coil and proper screening and shielding arrangements, these obstacles have largely been removed from the path of continuous, successful operation of the equipment.

V. Operation of Equipment

(1) Temperature Distribution At frequent intervals a temperature distribution investigation is made for the complete temperature range over which viscosity measurements are made.

For this purpose a special dummy crucible is used in place of glass. This crucible, containing a narrow tube in the center enclosed by Alundum cement, is placed in the furnace which is brought to some convenient temperature within the desired range. A long, carefully calibrated exploring thermocouple is then lowered from the top of the furnace so that the junction occupies various positions along the central axis of the crucible. Temperature measurements are taken and the current in each coil adjusted till the temperature over the entire length of the crucible is uniform to ± 1°C.

A record is then made of all thermocouple, current, and rheostat readings. Further, a careful comparison is made of the readings of the exploring thermocouple in the crucible and the thermocouple attached to the radio tube to ensure that their readings are identical. The divergence never exceeds 1°C. Similar operations are carried out to obtain satisfactory uniformity of temperature at intervals of 100°C over the range. Thus in a viscosity run the exact settings are known for each temperature desired and there is a good degree of assurance that the temperature distribution is satisfactory, longitudinally and radially.

Before making any viscosity determination, the desired temperature is maintained for at least one hour.

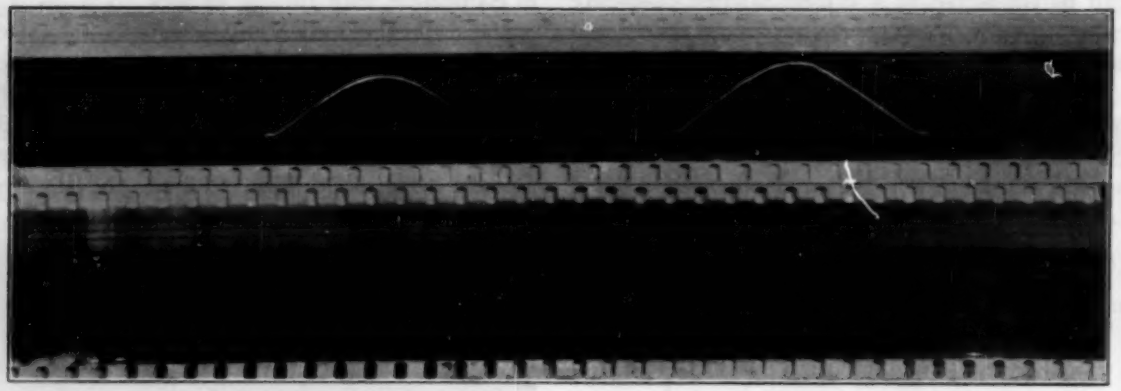

FIG. 7.—Oscillograph chart.

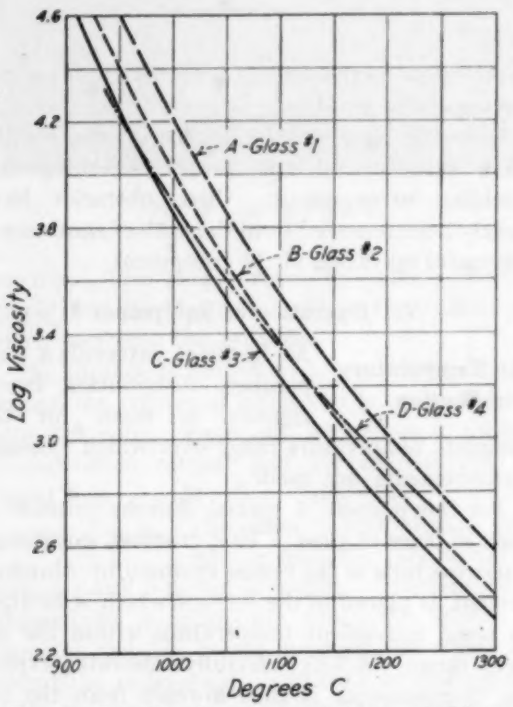

FIG. 8.—Log viscosity; temperature curves of four typical glasses.

VI. Results

So far there has been comparatively little evidence of inconsistency in results. Check runs have been made on several glasses with excellent agreement. Occasionally, due to local variations, such as voltage fluctuations during the course of a run, an individual result may be out of line by 1 to 3%. This, however, is an infrequent occurrence.

Agreement between values obtained for balls of different diameter has been satisfactory. For example, recent results for balls of 10 and 12 millimeter diameter at 1203.5°C gave log viscosity values 3.07(2) and 3.07(7), the agreement being closer than 1%.

It was thought that possibly the analysis of the glass might change during the course of the run. Several glasses have been analyzed before and after a determination with no appreciable change. The alumina acquired from the sillimanite crucible was found to be small. Samples of glass taken next to the crucible wall were found to have picked up 0.15% alumina.

This method is perhaps somewhat elaborate and difficult to use. However, once under control, there would seem to be good reason to believe that values obtained give an accurate picture of the viscosity of any glass subjected to examination.

Comparison runs were made on two glasses

(Nos. 1 and 4 below) by this method and by Lillie at Corning using the rotating cylinder method. Results were in excellent agreement, particularly in view of the striking contrast in the methods. The deviation of results might well be accounted for on the basis of temperature measurement.

Results are given below on four typical glasses whose viscosities were investigated by the above method. (See Fig. 8.)

CHEMICAL ANALYSIS

	No. 1		No. 2		No. 3		No. 4	
SiO_2	73.97		74.35		72.27		62.50	
R_2O_3	0.91		0.85		1.72		1.30	
CaO	5.69	9.26	9.03	9.21	8.79	9.14		
MgO	3.57		0.18		0.35			
Na_2O	15.30		15.30		16.88		7.50	14.20
K_2O							6.70	
BaO	0.50		0.34					
PbO							22.00	

VISCOSITY

	No. 1		No. 2		No. 3		No. 4	
Temp. (°C)	Log N	N	Log N	N	Log N	N	Log N	N
900					4.71	51,300		
950	4.60	39,800	4.39	24,600	4.24	17,400	4.21	16,200
1000	4.20	15,850	4.00	10,000	3.85	7,080	3.89	7,760
1100	3.54	3,470	3.37	2,340	3.24	1,740	3.34	2,190
1200	3.02	1,050	2.85	708	2.74	550	2.91	813
1250							2.72	525
1300	2.58	380	2.42	263	2.33	214		

The difference in the viscosity of glasses containing dolomite and calcite lime is shown up well by the results for glasses 1 and 2. The substitution of 3.34% CaO for an equal amount of MgO reduces the viscosity over 30% for the range investigated. In line with the results of English,[13] No. 2 has a slightly slower setting rate in the vicinity of 1100°C, but the difference would not be expected to be appreciable in actual practice.

Glass No. 3 illustrates the effect of increasing the Na_2O content at the expense of silica. Its viscosity, compared to that of glass No. 2, is 30% lower at 950°C and 20% lower at 1200°C. The greater viscosity decrease at 950°C illustrates the effect of soda in lengthening the working range.

Glass No. 4 has quite a different viscosity range. The characteristic slow setting rate of lead glasses is evident from the slope of the curve.

During the past year many glasses, commercial and experimental, have been investigated. While some results have only confirmed what has already been observed in practical operation, a number of interesting points have come out which it is hoped will make a contribution to the improvement of commercial bottle glass as it exists today.

Acknowledgment The author wishes to acknowledge with appreciation the services of the staffs of Arthur D. Little, Inc., and the General Radio Corporation in designing and developing this apparatus.

RESEARCH DEPARTMENT
OWENS-ILLINOIS GLASS COMPANY
ALTON, ILLINOIS

[13] S. English, *Jour. Soc. Glass Tech.*, **8**, 205 (1924).

THE EFFECT OF MECHANICAL PRESSURE ON THE DRYING AND FIRING PROPERTIES OF TYPICAL CERAMIC BODIES*

By A. E. R. Westman

ABSTRACT

The drying and firing properties of hand-molded and permeable-pressed disks, $2^3/_4$ inches in diameter and $1^1/_2$ inches thick, were determined for sanitary ware, semivitreous ware, electrical porcelain, glasspot, sewer pipe, and chemical stoneware. Permeable pressing at 8280 lb./sq. in. eliminated drying shrinkage, reduced firing shrinkage by nearly one-half, and the combined shrinkage by from one-half to two-thirds. The majority of the disks were dried and fired successfully, but some cracked on drying, probably from thermal shock, and some pressed disks were insufficiently oxidized or reduced due to their dense structure. Studies of pressing times showed great differences between bodies and, for any one body, that the pressing time depended roughly on the square of the initial thickness of the disk.

I. Introduction

(1) Previous Communications In two previous papers[1] experiments were described in which a number of ceramic clays in the plastic condition were held between water-permeable pistons under mechanical pressures of 207, 8280, and 16,560 pounds per square inch in contact with water at atmospheric pressure until equilibrium was reached; the water in the pistons was removed by compressed air, the mechanical pressure released, and the moisture content, density, drying shrinkage, and other properties of the clays were determined. It was found that the effects of the shrinkage stage in drying were obtained at relatively low pressures approximating those required to overcome the capillary suction of the clays, that higher pressures gave higher dry densities than air drying, and that clays of the ball-clay and china-clay types were sharply differentiated at low pressures but not at high pressures.

In a further series of experiments, described in paper II,[1] the effect of a series of pressures on two distinctive clays was investigated as well as the effect of mixing clays and adding nonplastics. The firing properties of the permeable-pressed clays were also reported. It was found that with Florida kaolin all but a small persistent drying shrinkage was eliminated by pressures greater than 2800 pounds per square inch, and that lower pressures reduced the dry volumes of the disks without preventing drying shrinkage; with Delaware kaolin, a pressure of about 300 pounds per square inch eliminated drying shrinkage completely; with both clays at high pressures, a considerable increase in volume took place on the release of pressure. A mixture of Georgia and Florida kaolin behaved similarly to the clays themselves. Nonplastics, when added to clays, produced a lack of recoil on release of pressure which appeared to be typical of fire clays having a high nonplastic content. Preliminary firing tests of $^1/_4$-inch thick disks showed no warping or lamination at cone 9+. The decrease in total dry volume of the disks due to permeable pressing resulted in a marked decrease of firing shrinkage in clays fired to vitrification and in a decrease in fired volume and porosity with little change in firing shrinkage with clays which were only slightly vitrified.

(2) Present Communication In all the experiments described in the previous paragraph rather thin disks of clay, $1^3/_4$ inches in diameter and $^1/_4$ inch thick before pressing, were used. The use of thin disks was an advantage in experiments with a number of clays and pressures, since equilibrium was reached more quickly, but made it difficult to study pressing rates and to detect possible laminations, etc., which might be introduced in pressing.

In the experiments now to be described a larger press was used with which it was possible to press disks $2^3/_4$ inches in diameter and up to $1^1/_2$ inches in thickness, and thus to study rates of pressing and to detect possible drying and firing difficulties. Both commercial bodies and clays were investigated.

(3) Pressing Apparatus and Procedure The permeable press that was used in the present study was similar in design to that described in detail in paper I[1] and consisted of two permeable pistons and a ring which were surface-hardened and ground to a close fit. The ring was $4^1/_2$ inches long with an outside diameter of $4^1/_4$ inches and inside diameter $2^3/_4$ inches, with

* Presented at the Annual Meeting, American Ceramic Society, Cincinnati, Ohio, February, 1934 (White Wares Division). Revised copy received March 13, 1934.

[1] A. E. R. Westman, "The Effect of Mechanical Pressure on the Imbibitional and Drying Properties of Some Ceramic Clays, Part I," *Jour. Amer. Ceram. Soc.*, **15** [10], 552–63 (1932); "Part II," *ibid.*, **16** [6], 256–64 (1933).

the rest of the apparatus of proportionate dimensions. Similar arrangements were provided for removing the water in contact with the pressed disk before releasing the pressure. Arrangements were provided by means of which movements of the pistons could be read to one-hundredth inch, which was sufficiently sensitive for the type of experiment undertaken.

The procedure followed was essentially similar to that used in the previous work but some small changes were made. It was found desirable to use slightly oversize filter papers in contact with the clay in the press, the excess being crimped in a regular fashion so that it extended about 2 millimeters along the wall of the ring. This helped

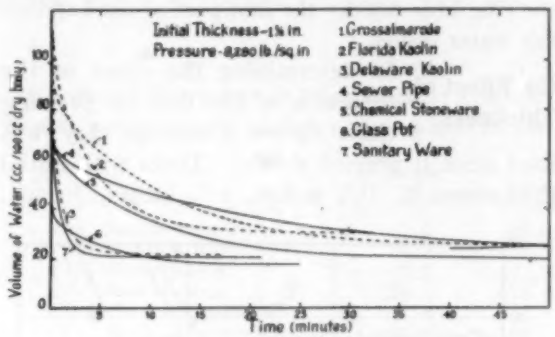

FIG. 1.

to prevent clay from getting between the pistons and the ring. The same pressure, 8280 pounds per square inch (the limit of the testing machine for $2^3/_4$-inch pistons), was used in practically all the tests; a pressure of about 85 pounds per square inch was applied just long enough to allow the plastic disk to conform to the inner surfaces of the press and then the pressure was raised to 8280 pounds per square inch in one-half minute or less. Timing started as soon as the pressure was increased above 85 pounds per square inch. In view of the size of the disks, weighing bottles were not used.

(4) Materials The materials used in the experiments included the following clays, which are described in detail in paper I[1]: Gross Almerode, Delaware kaolin, Florida kaolin, and Jernigan ball clay. The commercial bodies, which were secured from the manufacturers in the plastic state as they were normally used in practice, included a chemical stoneware, a sewer pipe, and a glasspot body; in addition, bodies typical of sanitary ware, electrical porcelain, and semivitreous ware were prepared in the laboratory. The compositions of the bodies are given in Table I. The last three are similar to those used by Parmelee and McVay[2] with some changes in the clays in order to use materials whose permeable pressing properties were known.

TABLE I

BODY COMPOSITIONS

Body	Composition
Chemical stoneware	Regular commercial body
Sewer pipe	10% fine red sand, 90% Aldershot sewer-pipe clay
Glass pot	40% grog, 20% calcined flint, 40% Gross Almerode clay
Sanitary ware	English china clay 26, Florida kaolin 8, Dorset English ball 10, flint 30, feldspar 26
Electrical porcelain	English china clay 30, Dorset ball 20, flint 20, feldspar 30
Semivitreous ware	English china clay 23, Florida kaolin 7, Delaware kaolin 9, Dorset ball 13, flint 36, feldspar 12

II. Pressing Rates

(1) Comparison of Clays and Bodies In the work with thin disks, it had been noticed that the time required to permeable-press clays at a given pressure depended to a considerable degree on the type of clay which was used. In order to investigate this more fully, a number of experiments were made in which the rate of pressing was determined for plastic disks originally $1^1/_2$ inches in thickness when subjected to a pressure of 8280 pounds per square inch, readings of the dial which measured the movement of the pistons being taken every 30 seconds. The initial and final moisture contents of the disks were determined and were used to calculate the moisture contents of the disks at different times during the pressing operation in terms of the volume of water per 100 cubic centimeters dry clay or body. Some error was introduced by compression of the permeable pistons, but calculations of the total moisture change from the total recorded piston movement showed that this error was not important.

The data obtained were used in preparing Fig. 1 in which the moisture contents, in terms of cubic centimeters of water per 100 cubic centimeters dry material, are plotted as ordinates and the time after raising the pressure above 85 pounds per

[2] C. W. Parmelee and T. N. McVay, "An Investigation of the Properties of Some Feldspars," *Univ. of Ill. Eng. Expt. Sta. Bull.*, No. 233 (1931).

square inch as abscissas, the curves for the clays being shown in broken line and for the bodies in full line. Readings were taken until the piston movement was less than 0.01 inch over a period of 4 or 5 minutes. It will be observed from the figure that the total time varied from 60 minutes for Gross Almerode clay to 7 minutes for the sanitary-ware body. The electrical porcelain and semivitreous ware gave curves which did not differ materially from the sanitary ware.

In all cases, pressing proceeded very rapidly during the first few minutes and then gradually slowed down as time went on. As shown by the figure, the materials differed greatly, not only in their initial and final moisture contents, but also in the shapes of their moisture-loss curves. A comparison of curves 1 (Gross Almerode) and 6 (glasspot body) shows how the introduction of grog and flint in such relatively large proportions lowered the initial moisture content, *i.e.*, the water of plasticity, to a much greater extent than the final moisture content. A comparison between curves 1 and 3 shows how two clays with similar initial moisture contents press at widely different rates. The sewer-pipe, chemical stoneware, and sanitary-ware bodies have similar initial moisture contents and quite distinct pressing curves. Because of the asymptotic character of the curves, it was difficult to fix the total pressing time with accuracy although the final moisture content could be determined precisely. To afford a quantitative comparison of the materials, therefore, the times required to remove 50 and 97.5% of the expressible water were calculated from the dial readings and are given in Table II.

TABLE II

PRESSING TIMES

(1 1/2-inch disks, 8280 lb./sq. in.)

Material	Time in minutes to remove indicated percentage of expressible water	
	97.5%	80%
Swansea sewer pipe	51	26
Chemical stoneware	33 1/4	13 3/4
Gross Almerode	33	15
Glasspot	16	7 1/2
Florida kaolin	15 1/2	6
Jernigan ball	9 1/2	7 1/2
Electrical porcelain	6 3/4	2 3/4
Semivitreous	5	2
Delaware kaolin	4 1/2	1 1/4
Sanitary ware	4	2

The data in the table show that the rates of pressing are strikingly different for the different materials, the sewer-pipe body taking about thirteen times as long as the sanitary-ware body to reach corresponding points on the pressing curves. The 80% times are roughly one-half the 97.5% times,

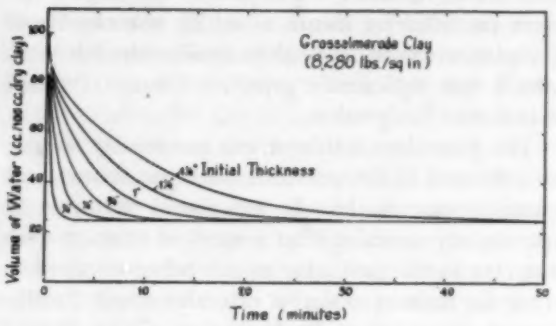

FIG. 2.

showing how rapidly the first part of the expressible water leaves.

(2) Effect of Thickness In determining the effect of the thickness of the disk on pressing time, Gross Almerode clay was used since it pressed slowly. Disks with initial thicknesses of 1 1/2 inches, 1 1/4 inches, 1 inch,

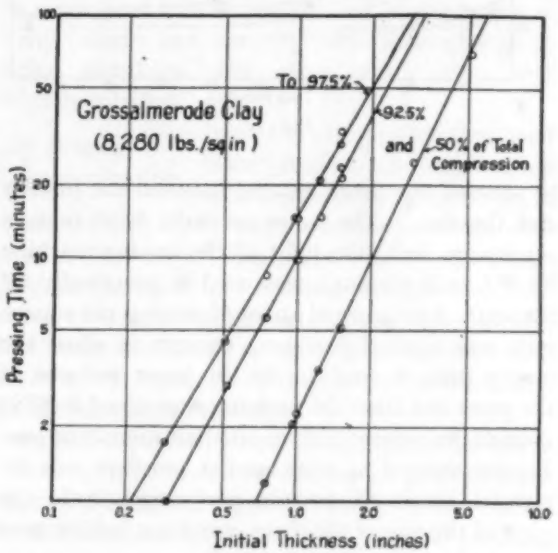

FIG. 3.

3/4 inch, 1/2 inch, and 1/4 inch were pressed at 8280 pounds per square inch and a series of pressing curves were calculated which are shown in Fig. 2. The initial and final moisture contents averaged 99.2 and 24.8 cubic centimeters per 100 cubic centimeters dry clay, respectively, and showed only a negligible variation. It is evident from Fig. 2 that thickness has a marked effect on the rate of pressing.

By the procedure described in the previous section, the times for 97.5, 92.5, and 50% pressing were calculated for the different thicknesses and plotted on a log-log chart as shown in Fig. 3. The linear relationship shown on the log-log chart corresponds to a parabolic relationship of the form

$$y = ax^b$$

in which y is the pressing time and x the initial thickness. The values of a for the 97.5, 92.5, and 50% curves were found to be 15.2, 10.6, and 2.3, respectively; and for b, 1.76, 1.93, and 2.18, respectively. Thus, the time of pressing varied in an approximate way directly as the square of the thickness. This is to some extent to be expected since, if we consider two disks, one of which is twice the thickness of the other, approximately twice as much water is moved through an average of twice the distance when the thicker disk is pressed.

III. Pressing and Drying Properties

(1) Procedure In order to determine the permeable pressing and drying properties of the bodies and clays, 1 1/2 inch thick plastic disks were pressed at 8280 pounds per square inch until the pistons showed less than 0.01-inch movement in 5 minutes. The excess water was removed from the press by compressed air, and the disk was removed, weighed, and then placed in kerosene. The standard procedure for drying properties was then followed. In drying, the disks were first placed in a well-ventilated drier operating at approximately 50°C and then transferred to one operating at 110°C. A 1 1/2 inch thick plastic disk which had not been pressed was given the same treatment. The experiments were made in duplicate.

(2) Cracking on Drying Some cracking on drying was encountered in the case of some of the pressed disks of Gross Almerode clay, some of the pressed and unpressed disks of semivitreous ware, and one pressed disk of electrical porcelain. The cracks were largely radial in character and originated in indentations left by the crimping of the filter paper in the press. They were likely caused by thermal shock during the transfer from the 50°C to the 110°C drier since they occurred with mixtures having high free silica and with pressed disks which, as will be shown later, did not shrink appreciably on drying.

TABLE III

COMPARISON OF PROPERTIES OF DISKS MADE AT ATMOSPHERIC AND AT 8280 POUNDS PER SQUARE INCH GROSS PRESSURE

(Weights in grams per 100 grams dry body, volume in cubic centimeters per 100 cubic centimeters true volume dry body)

	Material	Wet disk				Dry disk (total vol.)	Drying change (total vol.)
		Weight of water	Total volume	Water volume	Air volume		
(1)	Sanitary ware	7.9	126.4	20.6	5.8	126.1	− 0.3
(2)	Sanitary ware	26.6	167.9	69.7	−1.8	144.7	−23.2
(1)	Semivitreous	7.9	127.7	20.9	6.8	127.3	− 0.4
(2)	Semivitreous	29.5	178.0	77.4	0.6	149.6	−28.4
(1)	Electrical porcelain	7.4	124.7	19.3	5.4	125.5	+ 0.8
(2)	Electrical porcelain	25.9	168.7	67.7	1.0	144.3	−24.4
(1)	Glasspot	6.7	122.9	17.9	5.0	121.1	− 1.8
(2)	Glasspot	16.1	146.4	43.1	3.3	130.7	−15.7
(1)	Swansea sewer pipe	8.6	124.7	23.0	1.7	123.4	− 1.3
(2)	Swansea sewer pipe	26.2	167.5	70.1	−2.6	135.7	−31.8
(1)	Chemical stoneware	7.8	126.5	20.7	5.8	130.1	+ 3.6
(2)	Chemical stoneware	29.0	180.4	76.1	4.3	145.9	−34.5

(1) Pressed disks
(2) Unpressed disks

(3) Pressing and Drying Properties The drying properties and pressing characteristics of the materials studied are shown in Table III, the data being expressed in the same manner as in the previous papers. The standard properties can be readily calculated from the data as described in detail in paper I.

In Table III, the data for the unpressed and pressed disks are given in alternate rows so that the effect of pressing will be readily apparent. It is evident from the table that permeable pressing at 8280 pounds per square inch resulted in all cases in a marked lowering of moisture content, wet volume, and dry volume and eliminated drying shrinkage. The increased air volume shown for the pressed disks of some of the bodies is due

to expansion of the disk when removed from the press, a phenomenon which is observed with some clays. The expansion on drying shown for the chemical-stoneware body is not due to an experimental error but is similar to that found for certain clays in previous work. Throughout the table, the data for the sanitary ware, electrical porcelain, semivitreous ware, and chemical stoneware are in approximate agreement. The heavily grogged glasspot body packs better and the sewer-pipe body not as well as the other bodies as shown by the data in the third column. The 17.9 cubic centimeters of water volume for the glasspot body corresponds to a pore space of less than 15%. The unpressed sewer-pipe body packs well in the dry state which increases its drying shrinkage.

Apart from the elimination of drying shrinkage, permeable pressing increases the packing in the dry state, as shown by the fifth column in the table. This increase is not as great with carefully compounded bodies such as the glasspot and chemical-stoneware bodies.

Similar data to that shown in Table III were obtained for some of the clays, but since they agreed very closely with those obtained on thin disks which have already been reported in papers I and II[1] they were not included in this paper.

IV. Firing Properties

(1) Procedure Both pressed and unpressed disks of all the bodies except sewer pipe were fired to cone 9 in a well-insulated gas-fired kiln with a uniform temperature distribution. The temperature of the kiln was raised at 50 to 1225°C, and then at 20°C to cone 9. Some of the glasspot disks were then refired to cone 12. The chemical-stoneware disks in this group were heated to approximately 900°C in an electric-muffle furnace to oxidize them and then packed in a sealed sagger with pieces of graphite in order to subject them to reducing conditions in the cone 9 firing. The sewer-pipe disks and some chemical-stoneware disks were fired in a regular commercial firing by the manufacturers supplying the bodies, the sewer-pipe disks being enclosed in a sagger to avoid salt-glazing.

(2) Fired Appearance A considerable interest attached to the appearance of the disks after firing since only thin pressed disks had been fired previously. It was found that there was no evidence of warping or cracking during the laboratory firing in the case of the pressed disks with the exception of the chemical-stoneware disks. With the chemical stoneware, two pressed disks had bloated badly due to insufficient oxidation in the oxidizing firing, and the two other pressed disks showed small bloated spots due to the same cause but were otherwise true and solid. The fired properties of the stoneware disk were determined on specimens prepared by chipping the bloated spots from the latter pair of disks. Fresh surfaces of the chemical stoneware showed the normal gray color of the ware fired in the plant.

The unfired disks acted normally in the commercial firings, but the pressed disks showed localized bloating due to insufficient oxidation in the case of the sewer-pipe body and insufficient reduction for the chemical stoneware. Both these effects were evidently due to the denser structure of the pressed disks. In determining the fired properties of the sewer-pipe disks, the unoxidized portions were discarded.

An examination of both polished and fractured surfaces of the fired specimens showed that the pressed disks were denser and more uniform in all cases. This was particularly noticeable in the case of the glasspot, semivitreous, and chemical-stoneware bodies. These differences were greater than would arise in practice because the hand-molded disks were not as dense as those produced commercially and tended to have a poor structure. However, the effect of pressing in closing up the body was unmistakable. The pressed chemical-stoneware disks fired in the plant showed definite cores of unoxidized material when fractured, and the commercially fired, pressed, sewer-pipe disks showed small black cores. The pressed chemical-stoneware disks fired in the laboratory showed extremely dense, uniform, gray surfaces when polished or fractured.

(3) Fired Volumes Volume data for the fired disks along with some volume data from the previous tables are shown in Table IV, all volumes being expressed in terms of 100 cubic centimeters true volume of dry body. Both the pressed and unpressed disks of the sanitary ware, electrical porcelain, and sewer pipe fired to a low open porosity and to a total volume very close to 100. For these bodies, the decrease in total dry volume caused by pressing is reflected in a decreased firing shrinkage, the pressed disks having a little more than one-half the firing shrinkage

of the unpressed disks. With the semivitreous and glasspot bodies, the pressed disks fired to much lower porosities than the unpressed disks so that the decrease in dry volume caused by pressing was not wholly reflected in the decrease in firing shrinkage. The change in total volume from the wet to the fired condition is in all cases very much less for the pressed than for the unpressed disks. This is particularly striking in the case of the chemical-stoneware body, the corresponding decreases in total volume being 22 and 70 for the pressed and unpressed disks, respectively, although the pressed disk fired to a denser product. The pressed disk of the glasspot body is of particular interest since the change in total volume from the wet to the fired state is only 6.0 cubic centimeters, about 4.5% by volume, or about 1.5% by linear measurement. The fired disk fitted into the press in which it was made with a clearance of less than $^1/_{64}$ inch.

V. Drying and Firing Properties

(1) Standard Data Although the method of presentation adopted in the preceding sections permits a clearer understanding of the factors involved in the change of drying and firing properties caused by permeable pressing than does the standard method, the latter permits readier comparisons and is more familiar to the average reader. For this reason some of the data were recalculated to standard form and are given in Table V in round numbers.

TABLE IV

COMPARISON OF THE PROPERTIES OF DISKS MADE AT ATMOSPHERIC PRESSURE AND AT 8280 POUNDS PER SQUARE INCH GROSS PRESSURE, BEFORE AND AFTER FIRING TO CONE 9

(All volumes in cu. cm./100 cu. cm. true volume dry body)

Material	Wet disk (total vol.)	Dry disk (total vol.)	Fired disk: Total volume	Fired disk: Open pores	Fired disk: Closed pores	Fired disk: True volume
(1) Sanitary ware	126.4	126.1	100.7	0.12	2.6	98.0
(2) Sanitary ware	167.9	144.7	101.5	0.16	3.3	98.0
(1) Semivitreous	127.7	127.3	101.2	1.1	3.7	96.4
(2) Semivitreous	178.0	149.6	110.6	8.9	5.5	96.2
(1) Electrical porcelain	124.7	125.5	101.5	0.08	3.2	98.2
(2) Electrical porcelain	168.7	144.3	103.4	0.0	5.1	98.3
(1) Glasspot	122.9	121.1	117.5	17.2	2.2	98.1
(2) Glasspot	146.4	130.7	127.5	26.8	2.6	98.1
(1) Glasspot (cone 12)	122.9	121.1	116.9	16.7	2.1	98.1
(2) Glasspot (cone 12)	146.4	130.7	126.9	26.1	2.7	98.1
(1) Chemical stoneware	126.5	130.1	104.5	0.18	8.6*	95.7
(2) Chemical stoneware	180.4	145.9	110.4	0.30	14.1*	96.0
(1) Swansea sewer pipe (1850°F)	124.7	123.4	102.5	0.17	6.1*	96.2
(2) Swansea sewer pipe (1850°F)	167.5	135.7	103.6	0.28	7.3*	96.1
(1) Pressed disks						
(2) Unpressed disks						

* These values should not be taken as typical of the corresponding commercial bodies.

TABLE V

DRYING AND FIRING PROPERTIES (in round numbers)

Body	Sanitary: Unpressed	Sanitary: Pressed	Semivitreous: Unpressed	Semivitreous: Pressed	Electrical porcelain: Unpressed	Electrical porcelain: Pressed	Glasspot: Unpressed	Glasspot: Pressed	Sewer pipe: Unpressed	Sewer pipe: Pressed	Chemical stoneware: Unpressed	Chemical stoneware: Pressed
Water of plasticity	27	8	30	8	26	7	16	7	26	9	29	8
Volume drying shrinkage	16	0	19	0	17	0	12	1.5	23	1	24	−3*
Volume firing shrinkage	30	20	26	21	28	19	2.5	3	24	17	24	20
Total volume shrinkage (fired basis)	65	26	61	26	63	23	15	5	62	22	63	21
Apparent porosity	0.2	0.1	8	1	0.0	0.1	21	14	0.3	0.2	0.3	0.2
Closed porosity	3	3	5	4	5	3	2	2	7†	6†	13†	8†

* 3% *expansion* on drying.
† These values are not to be taken as applicable to the commercial products.

VI. Conclusions

(1) Preface The following conclusions are based on experiments in which disks of plastic clays and ceramic bodies, $2^3/_4$ inches in diameter and up to $1^1/_2$-inch thickness were permeable-pressed at 8280 pounds per square inch, their rate of pressing, pressing characteris-

tics, and drying and firing properties being determined.

(2) Rate of Pressing The rate of pressing depended to a marked degree on the nature of the material. In all cases, the initial rate was rapid but fell off with time. The time of pressing varied roughly with the square of the initial thickness.

(3) Pressing and Drying Characteristics Permeable pressing eliminated drying shrinkage in all the bodies investigated and substituted a slight expansion in one case. It also decreased the total wet and dry volumes. In the case of the heavily grogged glasspot body, the pore space in the pressed disks when dry was less than 15%.

Some cracking on drying occurred with pressed and unpressed disks of some of the clays and bodies. The cracks originated in surface defects and were thought to be due to thermal shock. Some of the cracked disks suffered no volume change on drying.

(4) Firing Properties With normally close-firing bodies, permeable pressing at 8280 pounds per square inch reduced the firing shrinkage by somewhat less than one-half, and the total change from wet to fired volume by from one-half to two-thirds approximately. It also reduced the closed-pore volume. With normally open-firing bodies, permeable pressing decreased the fired porosity and thus had less effect in reducing firing shrinkage. The permeable-pressed glasspot disk showed a remarkably low change in size from the wet to the fired state, the total linear change being about 1.5% or less.

Firing the thick permeable-pressed disks presented no difficulty due to warping, lamination, etc., but with the sewer-pipe and chemical-stoneware bodies it appeared that the pressed disks, having a denser structure, would require longer oxidation and reduction periods than unpressed disks, carried out preferably at somewhat lower temperatures.

Acknowledgments The writer is indebted to H. B. Speakman, Director of the Ontario Research Foundation, for his interest and help, to F. J. Rutland, laboratory assistant, for loyal and careful laboratory work, and to the companies who supplied materials and fired specimens.

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A RAPID METHOD FOR THE ANALYSIS OF SILICEOUS REFRACTORIES*

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ABSTRACT

Evaporation with HF and H_2SO_4 removes silica. Ignition of residue at 800 to 900°C yields a mixture of R_2O_3 and sulfates, which is weighed. The residue is brought into solution and R_2O_3, CaO, and MgO are determined by standard methods. CaO and MgO are calculated back to sulfates and alkali is calculated from weight of ignited residue. Silica is found by difference. A summary of previous investigations of the behavior of sulfates at elevated temperatures is presented, as well as the results of similar experiments by the authors.

I. Introduction

The usual method of analyzing siliceous refractories is by sodium carbonate fusion, followed by double evaporation with acid to render silica insoluble, and precipitation of the bases. When the alkalis are determined, the J. Lawrence Smith fusion is generally employed.

The estimation of silica by evaporation is by no means the simple procedure that it appears to be, and very few analysts can obtain consistent duplicates within several tenths per cent. Therefore, for a material high in silica, such as silica brick, it seemed desirable to devise some means of determining the small amounts of bases and alkali and to estimate silica by difference.

Such a method has been found in evaporating the sample with hydrofluoric and sulfuric acids, volatilizing the silica, and igniting the residue to a weighable mixture of R_2O_3 and sulfates, from which by subsequent treatment, all the bases can be separated and the alkali calculated.

This method has the great advantage of speed over the fusion method. It also accomplishes the estimation of alkali in the very small percentage present without recourse to the Smith fusion.

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* Presented at the Annual Meeting, AMERICAN CERAMIC SOCIETY, Pittsburgh, Pa., February, 1933 (Refractories Division). Received June 2, 1933.

II. Procedure

One gram of the powdered sample for analysis is weighed into a platinum crucible and moistened with water. About 20 milliliters of 40% hydrofluoric acid and 20 to 30 drops of concentrated sulfuric acid are added, and the crucible is placed on the hot plate for evaporation. Four to five hours are required to remove most of the hydrofluoric acid and to carry away the silicon fluoride. The crucible is then more strongly heated to fume away the sulfuric acid, decompose the fluorides, and make certain the removal of fluorine. The open crucible is next heated for ten minutes at 800 to 900°C in the flame of a Fisher or Méker burner. This treatment converts the sulfates of titanium, aluminum, and iron to oxides, leaving calcium, magnesium, and sodium as sulfates.

The crucible is then cooled and weighed and the weight of the contents recorded. The mixture of oxides and sulfates is removed from the crucible by digestion with hydrochloric acid. It is difficult to get complete solution because of the slow reaction of ignited oxides with acid, but it seems to be unnecessary to obtain complete solution before the usual ammonia precipitation. R_2O_3, CaO, and MgO are successively determined by the usual methods.

The R_2O_3, after weighing, is fused with pyrosulfate, and the melt is dissolved and treated with hydrogen peroxide for the detection and estimation of TiO_2.

From the above results are calculated the weights of $CaSO_4$ and $MgSO_4$ present in the ignited residue from the original evaporation. These are added to the weight of R_2O_3, and the sum is subtracted from the weight of the residue. The remainder represents alkali sulfate from which Na_2O is calculated.

The assumption is made here that the alkali is entirely Na_2O. This is not, of course, altogether justifiable. But the error is only 0.02% for each 0.1% K_2O replacing Na_2O. Silica is now found by difference.

(1) Applicability The method is applicable in general to all refractory materials that are completely decomposed by hydrofluoric and sulfuric acids. It is especially adapted to the analysis of silica brick. Glasses offer some difficulty in the ignition because the relatively large amount of Na_2SO_4, forming $Na_2S_2O_7$, resists decomposition and may require as long as two hours to reach constant weight.

NOTE: It is possible, in the absence of large amounts of alumina and alkali, to subject the crucible to a second ignition at 1100°C, in a reducing atmosphere created by enclosing the flame of a Fisher blast burner in a hollowed-out insulating brick, and thus to volatilize the alkali completely and convert calcium and magnesium to oxides. This step is found to add nothing to the accuracy of the method and is not recommended.

III. Results Obtained

Several samples of siliceous materials were analyzed according to the scheme outlined (p. 136). The results as compared with the usual Na_2CO_3 fusion method are given. The alkali in the latter analyses was determined by the J. Lawrence Smith procedure.

IV. Behavior of Sulfates at High Temperatures

The decomposition of sulfates by heat has been studied by several investigators. Marchal[1] determined that Al_2O_3 caused rather rapid decomposition of Na_2SO_4 above 1200°C, while Na_2SO_4 alone showed 4.23% loss at 1300°C for three hours. Investigation of the stability of Na_2SO_4 and K_2SO_4 by the present writers showed no loss in weight at the temperature of heating prescribed in this analytical procedure.

Marchal[2] also studied the decomposition of $CaSO_4$. Pure $CaSO_4$ has a pressure of SO_3 of 8 millimeters at 1000°C, and 67.7 millimeters at 1200°C. Fe_2O_3, SiO_2, Al_2O_3, and kaolin raised the pressure, and kaolin was found to produce 1070 millimeters at 1170°C.

Zawadzki *et al.*[3] reported that $CaSO_4$ with carbon yielded CaS at 900°C; the latter combines with $CaSO_4$ to produce CaO and SO_2. $MgSO_4$ and carbon above 320°C gave MgO and SO_2. CO reduced $CaSO_4$ almost quantitatively between 700° and 900°C, and the CaS decomposes

[1] (*a*) G. Marchal, "Decomposition of Na_2SO_4," *Bull. Soc. chim. France*, **45**, 225 (1929); *Ceram. Abs.*, **9** [10], 832 (1930). (*b*) G. Marchal, "Action of SiO_2 and Al_2O_3 on Na_2SO_4," *Compt. rend.*, **188**, 258–60 (1929); *Ceram. Abs.*, **8** [6], 449 (1929).

[2] G. Marchal, "Thermal Decomposition of Sulfates," *Jour. chim. phys.*, **22**, 559–82 (1925); *ibid.*, **23**, 38–60 (1926); *Chem. Abs.*, **19**, 1167 (1926).

[3] (*a*) J. Zawadzki, J. Konarzewski, W. J. Lichenstein, S. Szymankiewicz, and J. Wachstijuski, "Decomposition of Alkaline Earth Sulfates, I, II, III," *Roczniki Chem.*, **5**, 488–50 (1925); **6**, 120–35, 236–55 (1926); *Chem. Abs.*, **20**, 3142 (1926); **21**, 2232 (1927).

(*b*) J. Zawadzki, I. Kawalaczewski, and S. Zeromski, "IV," *Roczniki. Chem.*, **8**, 358–68 (1928); *Chem. Abs.*, **23**, 1834 (1929).

above 900°C to CaO. Budnikoff and Syrkin[4] found that $CaSO_4$ at 1375°C had a dissociation pressure of 1 atmosphere and began above 800°C. Bhatt and Watson[5] and Losev and Nikitin[6] found similar decomposition behavior of $CaSO_4$.

The information in the literature indicated that the alkali sulfates were fairly stable, while the alkaline earth sulfates were stable only under oxidizing conditions. The presence of CO readily broke down the alkaline earths into oxides. The instability of $Fe_2(SO_4)_3$ and $Al_2(SO_4)_3$ is well known.

During this investigation, pure salts were heated in an open crucible over a Fisher burner for 15 minutes. It was found that $Fe_2(SO_4)_3$ and $Al_2(SO_4)_3$ broke down completely into oxides. $CaSO_4$ and $MgSO_4$ showed no loss in weight. Continued heating did cause a slow decomposition of the $MgSO_4$ to MgO. K_2SO_4 and Na_2SO_4 were unaffected by similar heating.

When the alkaline earth sulfates were heated under reducing conditions for one hour at 1100°C, complete breakdown to oxides occurred. The alkali sulfates were completely volatilized by similar treatment, probably as sulfides.

	Glass							
	$HF \cdot H_2SO_4$	Na_2CO_3						
SiO_2, Al_2O_3, Fe_2O_3	71.8 0.6	71.7 0.6						
CaO	12.9	12.8						
MgO	Trace	Trace						
Alkali as Na_2O	14.6	14.8						
Ignition loss	No data	No data						
	Silica Brick						Bureau of Standards No. 102	
	$HF \cdot H_2SO_4$	Na_2CO_3[a]	$HF \cdot H_2SO_4$	Na_2CO_3[a]	$HF \cdot H_2SO_4$	Na_2CO_3[a]	$HF \cdot H_2SO_4$	Na_2CO_3
SiO_2	96.45	96.46	96.14	95.94	96.62	96.50	93.99	93.93
Al_2O_3	1.57		1.54		1.43		2.20	2.17
Fe_2O_3							0.72	0.66
CaO	1.68		1.82		1.60		2.29	2.29
MgO	0.10		Trace		0.05		0.24	0.21
Alkali as Na_2O	0.20		0.10		0.20		0.17	0.35
Ignition loss	No data		0.10		0.13		0.39	0.38

[a] Sample and data on silica furnished by R. H. H. Pierce, Harbison-Walker Refractories Co., Pittsburgh, Pa.

[4] P. P. Budnikoff and J. K. Syrkin, "Dissociation of $CaSO_4$ at Higher Temperatures," *Chem.-Ztg.*, **47**, 22 (1923); *Chem. Abs.*, **17**, 1745 (1923).

[5] L. A. Bhatt, and H. E. Watson, "Decomposition of Alkaline Earth Sulfates," *Jour. Indian Inst. Sci.*, **A10**, 117–29 (1927); *Ceram. Abs.*, **7** [10], 706 (1928).

[6] K. I. Losev and S. N. Nikitin, "Pyrogenous Decomposition of Gypsum," *Jour. Chem. Ind.* [Moscow], **6**, 169–73 (1929); *Chem. Abs.*, **24**, 3089 (1930).

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OBSERVATIONS ON SPALLING*

By F. W. Preston and H. E. White

ABSTRACT

If a sphere of clay at room temperature be immersed suddenly in a red hot furnace, spalls fly off its surface. These spalls are more or less circular disks, of somewhat definite thickness. They do not form instantly, but a finite time elapses between immersion and spalling. This time interval also is consistent and definite.

The hotter the furnace, the shorter the time interval and the thinner the spall.

According to the experiments, the thickness of the spall is proportional to the square root of the time interval; it is also inversely proportional to the fourth power of the absolute temperature. The first relation implies, apparently, that the controlling factor in the clay is the thermal diffusivity; the second relation implies that the connection between the clay and the furnace is radiant heat. Both implications seem entirely sensible.

The addition of an inert material of relatively high diffusivity accentuates the rôle that this factor plays in the resistance to spalling of clayware. These experiments were carried out by adding SiC flour in increasing amounts to the clay batch.

The views of the Refractories Division are sought before extending the work to geological problems.

Part I

By Frank W. Preston

I. A Spall Defined

A "spall" is a piece of stone larger than a "chip," but small in comparison with the stone from which it comes. With a hammer one may knock a spall from the edge of a brick, but if one breaks the brick into two equal halves, the halves are not spalls.

A spall is properly a flake-shaped piece; it is thin one way, namely, in a direction perpendicular to the original face. Equi-axed fragments are not properly spalls. When a bricklayer trims half an inch from the length of the brick with his hammer, the fragments are spalls. The chips that came off the edge of many a paleolithic flint spear-head were small spalls (Fig. 1). They were little flakes. The conchoidal (shell-like) flake that came off the piece of optical glass shown in Fig. 2, when it was hit on the corner by a hammer, was a spall.

Spalls may be made mechanically or may be produced by changes of temperature. The bricklayer and old stone age hunter are concerned mainly with the mechanical spalls. The average ceramist is concerned more with thermal failures.

The relative size and the flaky shape of spalls have been stressed because ceramists are using the term "spalling" in too broad a sense. They are beginning to speak of any fracture, arising from thermal causes, as spalling. If a block of refractory cracks through the middle, that is not a spall in the proper sense of the word; and this is true whether the crack arises from a hammer blow or from thermal shock. A spall is a flake from the surface.

This is not a matter simply of the King's English because the mechanism of a true spall, a surface flaking, is not altogether identical with the mechanism of other thermal fractures. It is necessary for the discussion that follows to have a clear definition of what the present writer at least means by a "spall."

There is a further characteristic of spalls that will probably be conceded to be a fundamental feature. Spalls must "fly off." That is, they must form somewhat suddenly and with enough violence to make at least something of a "pop" or audible noise. A crack opening slowly and silently in drying mud or cooling glass is not a spall.

The distinction between spalls proper and major fissures may be brought out by a simple experiment. A number of spheres of clay free from grog were made up about 3 inches in diameter. They were dried for two or three weeks at 100°F. A cubical electric furnace, with a space some 6 inches cubed, was then heated to a steady temperature, usually between 900°F and 1800°F. A clay ball, supported on a mesh of "chicken-wire" (wire netting), was then suddenly introduced into the middle of the furnace in such a way that it nowhere touched the furnace walls or floor but merely received radiant heat from them.

At the higher temperatures (1500°F and upward) only a few seconds elapsed until a violent popping began, as spalls were flung off from the surface. The ball was then withdrawn as quickly as possible and it was found that a number of pockmarks, perhaps 1/4 inch in diameter and a few hundredths of an inch thick, had been formed

* Presented at the Annual Meeting, American Ceramic Society, Cincinnati, Ohio, February, 1934 (Refractories Division). Received February 15, 1934.

in its surface where spalls had been thrown off (Figs. 3 and 3*a*).

If somewhat lower temperatures were used (1400°F), the time required for spalling to start was longer and the spalls that formed were thicker.

FIG. 1.—Mechanical spalls. Reading from left to right, Nos. 1 and 3 are Redskin arrow-heads of flint of the paleolithic type; Nos. 2 and 4 are glass replicas chipped by George P. Riggs of St. Marys, W. Va. (Photograph by H. E. White of Zelienople, Pa.)

If still lower temperatures were used (1200°F), the time was still longer and the spalls still thicker; but a new phenomenon now appeared. The first crack to form was not a spall at all, but a diametral fissure dividing the sphere into halves (Fig. 4). Frequently two subsidiary fissures would develop, dividing the hemispheres into quadrants (Fig. 5). These hemispheres or quadrants did not fall apart completely except on jarring, but they provided an open face from which true spalls could, and often did, start. At the lowest temperatures at which diametral fissures formed, there was sometimes no spalling proper.

FIG. 2.—Mechanical spall. A "conchoidal" fracture on a block of optical glass. (Photograph by W. M. Hampton, Chance Brothers, W. Smethwick, England.)

At temperatures of about 1000°F, no fissures of any sort formed because the stresses developed by sudden heating were not sufficient to produce fractures, either spalls or major cracks.

At the highest temperatures used (1700°F or so) diametral fissures never formed and spalling was very violent; spalls were thrown off with enough violence to hit the ceiling of the room, if given a chance.

FIG. 3*a*.

FIG. 3.

FIG. 4.

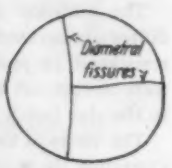

FIG. 5.

FIGS. 3 and 3*a*.—Thermal spalls. Pockmarks on a clay sphere suddenly heated, causing circular spalls to fly off violently. After the first circular flake flies off, others fly off contiguous to its margin, so that a group or cluster of the pockmarks tends to form. The pockmarked surface is a few hundredths of an inch below the level of the rigid surface.

FIG. 4.—Thermal spalls. A semi-diametral crack, having some of the properties of a large pockmark spall. The rim is much deeper than in Fig. 3, but equally well defined. The fracture is produced at a lower temperature.

FIG. 5.—Diametral fractures. Low-temperature effects. There is an effort made to divide the ball into quadrants.

It became apparent, as expected, that the time required to spall was less as the temperature was higher; and as the spall forms for the purpose of separating the heated rind from the cold core and thereby relieving the stress, the thickness of the spall was less as the time required to spall was less; or, the spalls were thinner at the higher temperatures.

There was no great difficulty in timing the interval between immersing the ball in the furnace and the sound of the first "pop." This is known as the "time required to spall." In general there was no difficulty in recovering a fair collection of spalled fragments and in measuring them with

the micrometer. Some variation of thickness was, of course, found, but there was a fair measure of uniformity and a reasonable mean of a dozen measurements was usually adopted.

In Fig. 6 the time required to spall is plotted against the temperature difference between furnace and ball core. The curve is more or less of a rectangular hyperbola: it is asymptotic to a vertical line at about 1000°F temperature difference, and presumably asymptotic to the horizontal axis, $t = 0$.

In Fig. 7, the time required to spall is plotted against the thickness of the spall formed. The curve among the observed points is drawn accurately as an ordinary quadratic parabola with its

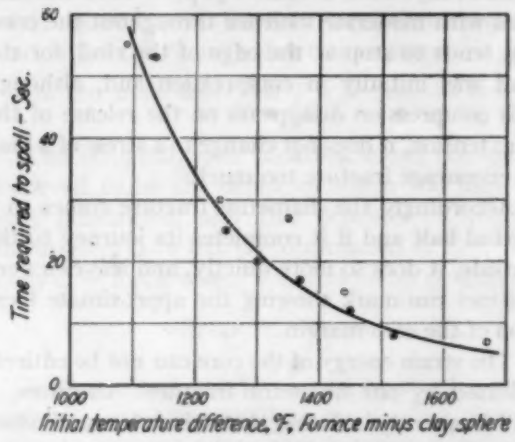

FIG. 6.—Time to spall plotted against thermal-shock temperature.

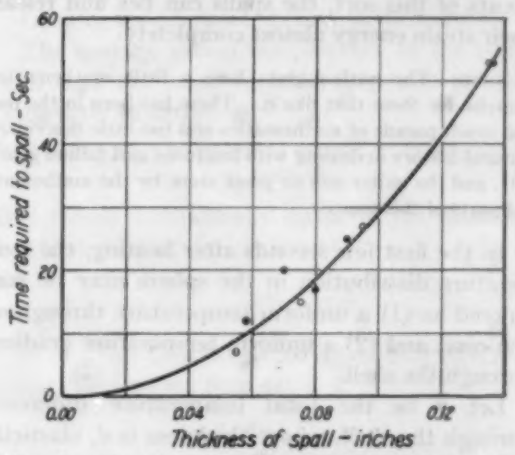

FIG. 7.—Time to spall plotted against thickness of spall formed.

vertex at the origin and passing through the most remote observed values. It seems to fit the other observed values as accurately as any arbitrary line could, and it would therefore seem that the thickness of the spall is proportional to the square root of the time required to spall.

II. The Mechanism of Spalling

The effect of suddenly heating the sphere on the outside is to produce a rind in tangential compression and a core in radial tension. This is a somewhat simplified conception of the stresses, but is correct as far as it goes.

If the heating be very sudden and severe, the stresses are initially much more severe in the rind than in the core. In fact, if the sphere be large, practically all the strain-energy is, for the first few seconds, concentrated in the rind. This energy is mainly compressional energy and glass and ceramic ware at room temperature do not fail in compression. A dilemma thus arises: the highly stressed parts are stressed mainly with a stress that does not produce fracture. The parts that are stressed with a tensile stress (which alone induces fracture) are not stressed heavily enough to fracture.

It therefore comes about that sudden heating does not produce instantaneous fracturing. The initial system of stresses is not of the type to produce fracture. There is a delay of quite definite amount while the stress system, so to speak, penetrates further into the specimen.

In several of the instances tabulated and graphed the delay was over 50 seconds. In another series of tests instances were found of delays of 110 seconds.

It is often convenient in analyzing the fracture-needs of an over-stressed brittle substance to consider not so much the stresses as they exist before fracture, but the strain-energy system and the effect of different sorts of fracture on releasing strain energy.

In the present instance there is a rind that wants to expand and a core that wants to stay of its original size. Evidently, if the rind could part from the core, forming a spherical shell detached from and slightly larger than the core, a good deal of strain energy could be released. Thus, parting along the interface of core and rind is one of the primary objectives of spalling when the spalling is due to sudden and violent heating of a body.

But this parting will not release all the strain energy. The core will be left stressless, but the

rind at the moment of spalling is hotter on the outside than on the inside, very much hotter. In consequence, the spherical shell assumes a size appropriate to its mean-radius temperature; this leaves the outside of the shell still in compression (though not so much so as when it was attached to the core) and the inner face of the shell is in tension. The shell therefore breaks into pieces from the inside outward. In practice, instead of first forming a shell and then breaking into pieces, the pieces fly off from the core in the form of true spalls, more or less circular flakes, half an inch or so in diameter and a few hundredths of an inch thick.

By breaking down into sufficiently small fragments of this sort, the spalls can flex and release their strain energy almost completely.

NOTE: The author gives here a little mathematical exercise for those that like it. There has been in the past too much parade of mathematics and too little descriptive natural history in dealing with fractures and failure generally, and the writer sets no great store by the mathematical parts of this paper.

In the first few seconds after heating, the temperature distribution in the sphere may be considered as (1) a uniform temperature throughout the core, and (2) a uniform temperature gradient through the shell.

Let $\tilde{\theta}$ be the total temperature difference through the shell, whose thickness is d, elasticity E, coefficient of expansion α. Let the core be very massive in comparison with the shell.

Then before fracture, the maximum strain developed is $\alpha\tilde{\theta}$. The strain energy per unit volume at the extreme surface is $E(\alpha\tilde{\theta})^2/2$. The strain energy of the shell as a whole is proportional to $E(\alpha\tilde{\theta})^2/d$.

This energy is expended primarily on providing an interface between rind and core, and this interface is of substantially constant size, whether the spall be very thin or only moderately thin, because the core is supposed to be by far the more massive part and to occupy virtually the whole volume of the sphere. Unfortunately, not all the energy is expended on this interface, for the fragments fly off with kinetic energy. Thus, the strain energy released can not be equated to the surface energy produced. If this could be done then it follows that spalling will take place when $E(\alpha\tilde{\theta})^2 d$ reaches a given value, and in that case $d\tilde{\theta}^2$ is constant.

Thus if, with a temperature-difference of 1100°F, the spall thickness is 0.13 inch, then with a temperature-difference of 1600°F, the spall thickness should be 0.06 inch. As a matter of fact this is nearly in accord with observations. The mathematical work, however, rests on very insecure foundations.

III. Heating Fractures Other Than True Spalls

(1) Diametral Cracks These occur when the temperature-difference is comparatively small. The temperature gradient works in a long way, without developing the ability of the rind to spall. A point is reached at which the radial tensions of the core cease to be negligible. The core then fractures diametrally with a faint "pop." This fracture runs with moderate violence throughout the core, but tends to stop at the edge of the rind, for the rind was initially in compression and, although this compression disappears on the release of the core tension, it does not change to a stress of a kind to encourage fracture too much.

Accordingly the diametral fracture comes to a partial halt and if it completes its journey to the outside, it does so more quietly, and leaves a very distinct rim-mark showing the approximate location of the core-margin.

The strain energy of the core can not be entirely released by one diametral fracture: therefore, it will frequently be found that others form, dividing the sphere into quadrants.

If spalls form, as well as diametral fissures, they are of a thickness substantially equal to the thickness indicated by the rim-mark on the diametral fractures.

In the tests of the writers, spalls tended to form on the upper and lower faces of the sphere and not on the sides. This was due undoubtedly to the fact that electric heating elements were on the upper and lower faces of the cubical furnace. Thus, the heating of the spheres was not uniform all around, though probably more so than in most furnaces.

The diametral fissures tended to form mainly on vertical planes. This, it seems reasonable to assume, was due to the same cause, for the sphere would be stretched more in the horizontal directions than in the vertical, and this would produce fractures at right angles to the horizontal plane.

The spalling of refractories on sudden heating is a somewhat more difficult operation than cracking them by sudden cooling. In the latter case

the outside goes into tension and tensile fractures like to begin at an outer face.

In the case of glass, it is practically impossible to crack a sphere by sudden heating. Joffé tried it[1] and found that the glass would stand internal stresses of many hundreds of thousands of pounds per square inch. Even so fragile a thing as rock salt will stand the most violent sudden heating. Refractories are not quite so stubborn as they commonly have all sorts of internal discontinuities.

IV. Discussion of the Experimental Results

Two graphs are given, one connecting time-to-spall (T) with thickness of spall (L), and the other connecting time-to-spall (T) with difference of temperature ($\tilde{\theta}$) between furnace temperature and initial (or "core") clay temperature.

The first graph shows that T is proportional to L^2, or

$$T = CL^2 \qquad (1)$$

This is logical, since the thickness of the spall is believed to be the depth to which the heat has just penetrated, and this depends on thermal diffusivity, κ. κ has the dimensions L^2T^{-1}; and thus $C = 1/A\kappa$, where A is a *universal* constant.

$$\text{Then } T = \frac{1}{A\kappa} L^2 \qquad (1a)$$

In the second graph, convert to absolute temperature by adding 540°F to the abscissa, and call the new abscissa θ (absolute Fahrenheit degrees): as just stated, $\theta = 540 + \tilde{\theta}$.

It will then be found from the graph that $T\theta^4 = \text{constant} = B \qquad (2)$

Substituting from (1) $L^2\theta^4 = B/C$, or $L\theta^4 = \sqrt{B/C} = \text{constant.} \qquad (3)$

The logic of this is apparent, for θ^4 measures the rate at which heat is received by the clay from the furnace. It gets it by radiation and (assuming black body conditions),

Q = (quantity of heat received by 1 sq. cm. of clay per sec.)
$= K\theta^4$, where K is the Boltzmann constant.

The body (clay) re-radiates an amount, $K\theta_0^4$, where θ_0 is its own temperature, but this amount of energy is negligible when we are dealing with furnace heat on the one side and room temperature (or nearly that) on the other.

The heat received nearly all goes into raising the temperature of the rind, the part that will spall if the heat is sufficient. A little of it is converted into strain energy (which is the thing that causes failure), but it is an insignificant fraction of the whole.

The total heat received by 1 square centimeter in time, T, is QT, and it sinks in to a depth, L, given by $T = CL^2$, so that in terms of the depth of penetration

$$H = QT = CQL^2 \qquad (4)$$

We have to assume that in the case of sudden and violent heating, the heat gradient in the rind is linear, being (say) $\theta_2 + \theta_0$ at the surface, and θ_0 at the inner boundary of the rind. This approximation is not a bad one for violent heatings.

Let σ be specific heat of clay: ρ, its density.

The average excess temperature of the rind is $\theta_2/2$, and the sensible heat therein per square centimeter of surface is

(Vol. per sq. cm.) × density × sp. heat × av. excess temp.
$= L\rho\sigma\theta_2/2 \qquad (5)$

But this is substantially equal to the total heat received, as given by equation (4).

$$\text{Therefore, } CQL^2 = L\rho\sigma\theta_2/2, \text{ or } \theta_2 = \frac{2CQL}{\rho\sigma}. \qquad (6)$$

It will be convenient to substitute for Q its value $K\theta^4$, and we then get

$$\theta_2 = \frac{2KC}{\rho\sigma} \cdot \theta^4 L \qquad (7)$$

This gives the surface temperature of the sphere when the heat has penetrated to a depth, L. When the clay spalls, we can (afterward) find L by measurement, and therefore we can calculate θ_2 at this instant.

However, we have already established that $\theta^4 L$ is a constant (at spalling), *viz.*, $= \sqrt{B/C}$ from equation (3).

$$\text{Therefore } \theta_2 = \frac{2KC}{\rho\sigma} \sqrt{\frac{B}{C}} = \frac{2K}{\rho\sigma} \sqrt{BC} \qquad (8)$$

B and C are constants of the material found from the graphs; ρ and σ are constants of the material. K is the universal Boltzmann constant.

Hence, θ_2 is a characteristic temperature of the clay surface at which spalling occurs.

Whatever the furnace temperature, the clay survives until its surface reaches the temperature θ_2, and then it spalls.

Returning now to equation (7): at any particular furnace temperature, θ_2 for a given clay is

[1] A. F. Joffé (translated by L. B. Loeb), Physics of Crystals, McGraw-Hill Book Co., New York, 1928.

proportional to L; and L in this equation is the depth to which the heat has penetrated at any time, not necessarily at spalling time.

It follows that at a given furnace heat, there is a particular temperature gradient θ_2/L that is established at the start. The heat soaks in further as time goes by, but the *gradient* is constant.

This gradient varies as the fourth power of the furnace temperature (from equation 7).

NOTE: These results are approximations, and are more nearly true in proportion to the suddenness and violence of the heating. With slow heating, the gradient is substantially exponential.

The heating of the rind throws it into compression.

If α be coefficient of expansion, and E, Young's modulus, the stress developed at the skin is

$$E\alpha\theta_2 = f_c \text{ (say)} \qquad (9)$$

And since the clay spalls at constant θ_2, it spalls at constant f_c.

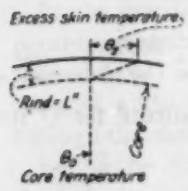

FIG. 8.

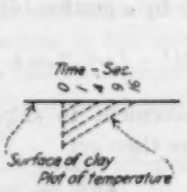

FIG. 9.

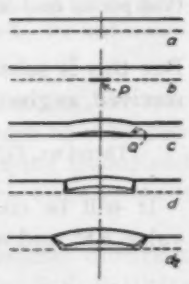

FIG. 10.

Mechanism of spall formation on sudden heating.

In other words, the clay spalls when a particular compressive stress in the skin is reached; this compressive stress may be calculated from equations (9) and (8).

But a compressive stress can not of itself break the clay. Clay does not fail in compression, but only in tension, and the question is therefore raised as to how these tensile stresses can arise. The process of spalling seems to the writer to be as follows: Heat soaks down to the dotted line in Fig. 10 (a). A flaw, lamination, or weakness is found at P in Fig. 10 (b). The rind wants to arch up and does so, Fig. 10 (c), extending the flaw. The reflexed arch at Q is now in tension on the underside, and cracks through, as at (d), or more correctly, as at (d_2).

The process is catastrophic. It is hard to get any leverage on the little flaw, P, but the leverage increases as the flaw extends, and the spall finally bends up with violence. It is easy to see that as it springs from configuration (c) to that of (d), it gives itself a sudden push outward, and therefore flings itself off with projectile-like violence.

In the absence of an initial flaw or weakness such as P, spalling by sudden heat is impossible. That is the reason why spheres of homogeneous rock salt or of glass can be immersed suddenly in molten metals at a great heat and not spall.

It seems that the tension causing spalling, that is, the tension in the refractory immediately around the weak zone, P, must increase with increase in the size of the discontinuity, P. Therefore, this tension can not readily be calculated from the surface compression, f_c. We must assume that the refractory's texture is such that a great number of such discontinuities as P exist here, there, and everywhere, and that they average around a particular size, and that therefore the relation between the tension developed and the compression, f_c, is substantially constant for a given refractory. This would explain, in general terms, the observation that f_c is in fact of constant value when spalling occurs.

It may be observed here that not only the size of the discontinuity, but its shape, is important. If the discontinuity be a spherical cavity, it will have to be much larger than a thin lamination parallel to the surface in order to be equally effective in starting a spall. Thus, a coarse-grained refractory full of rounded spongy holes may be stronger than a fine-grained one if the latter has laminar cavities.

V. Other Miscellaneous Conclusions

At spalling, the heat energy per cubic centimeter of spall is constant, *viz.*, CQL. At spalling, the strain energy per cubic centimeter of spall is constant, *viz.*, $\frac{1}{6} E\alpha^2\theta_2^2$.

The velocity with which spalls fly off should be (as a maximum) $v = \alpha\theta_2 \sqrt{\frac{E}{\rho}}$, and this seems to be independent of size of spall, which is rather remarkable. Apparently θ_2 could be calculated from this formula.

In the foregoing, some formulas are valid from first principles or from experiment: but others are approximations based on a linear thermal gradient, which can never be exact.

NOTE: The coefficient of expansion, α, used in equation (9) is there treated as an ordinary reversible linear coefficient of expansion. In most materials, the situation

is complicated by irreversible chemical or physical changes which take place on heating and involve sudden changes of length and volume. While this does not affect the original experimental results, regarded as purely empirical matter, and while it does not affect the mechanism of spalling envisaged in Fig. 8, it may easily affect the mathematical part of the argument. This argument may either be inadmissible, or it may be admissible subject to amendments.

Tentative solutions of certain geological problems have been arrived at in conjunction with Professor Blackwelder of Leland Stanford, and Dr. Insley of the Bureau of Standards, but the preliminary results are presented now in the hope that members of the Refractories Division may be able to assist with their experience.

BUTLER, PA.

Part II

BY H. E. WHITE

In the progress report on the investigation of sagger clay,[1] Heindl refers to data presented by Norton and Booze and Phelps, indicating a possible relation between resistance of firebrick spalling and the three factors, (1) modulus of elasticity, (2) thermal expansion, and (3) rate of temperature change or diffusivity. The statement is further made that diffusivity has been disregarded in this work. Norton states that diffusivity is not usually an important factor in the tendency of refractory materials to spall and gives a series of values for diffusivity of a number of fireclay brick which indicate a relatively small variation in this property under like conditions of heating.

Any one handling materials of high thermal conductivity has noticed their tendency to resist spalling.

Working along the lines that Dr. Preston has described, an investigation was made of the difference in spalling properties of materials of varying diffusivity and of relatively high diffusivity. Different materials were tried: fused mullite, crystalline alumina, and silicon carbide. It was found, of course, that silicon carbide which has a higher thermal conductivity than the other materials gave the widest range.

Three-inch spheres were made up similar to those worked with in the first half of this paper.

Granular materials of approximately 16-mesh mixed with bond clay were tried first. These were fired to normal firing temperature but it was not found possible to break them at the first cycle at normal attainable temperatures in laboratory furnaces.

This brings out another feature of the usual spalling test. In the panel spalling furnace, which simulates operating conditions quite closely, the face of the brick undoubtedly undergoes a thermal chemical change. It is generally admitted that failure occurs from this face breaking off. In order to overcome this tendency for gradual change by repeated heating and to make a study of true spalling it was necessary to have fractures occur at the first cycle. For this reason it was necessary to select the compositions of the materials worked with and also the physical state or temperature of firing and drying with this in view.

The first set of spheres was made using varying amounts of silicon-carbide flour and raw bond clay. The spheres were dried at 240°F and first tested in a gas-fired furnace at a temperature of 1450°F. No breaks or spalls occurred at this temperature which was higher than that necessary to start spalling in the earlier work but a different bond clay was used having a higher dry strength. This test minimized the indication that combined water in the clay alone might cause the popping off or spalling in the earlier work. Undoubtedly the combined water plays a part, but a rather small, part. If it were to be driven off it would be necessary to bring the spheres to such a temperature as to cause a change in state of the clay, increase the bond between the particles, and raise the furnace temperature so high that reasonably accurate observations could not be made.

The spheres containing the varying amounts of silicon-carbide powder were then tested in a furnace at a temperature of 2250°F. The results are shown in curve 1, Fig. 11, and curve 2, Fig. 14.

A set of these spheres was then calcined at 1450°F for an extended length of time and the test repeated. The first two having the lower concentration broke diametrally, the first one breaking into small pieces, the second breaking in two complete halves. The other three of the still higher SiC content did not crack. There can be no doubt of the higher diffusivity of the material when these tests were run as those of the higher silicon-carbide content came from the furnace as a glowing ball and remained hot for an extended period of time.

Another set of spheres was made up with varying amounts of silicon carbide, using bond clay,

[1] R. A. Heindl and W. L. Pendergast, *Jour. Amer. Ceram. Soc.*, **10** [7], 524 (1927).

calcined and finely pulverized, as a filler. The raw clay was then kept constant at 10%.

These spheres were tested in the same manner and after two minutes in the furnace at 1450° did not show signs of spalling the same as the first set. Upon examination, however, it was found that these spheres were actually fractured and had a loose rind, the thickness depending upon the concentration of the silicon carbide. This is graphically shown in Fig. 12 and in curve 3, Fig. 11.

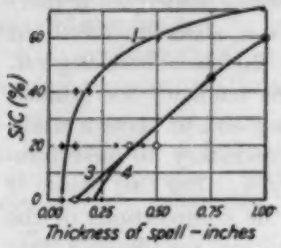

FIG. 11

This test was repeated with the furnace at 2250°F. The result is shown in curve 4, Fig. 11. The spalls were thicker at the lower concentration but were almost exactly the same at the higher silicon-carbide content as those shown in curve 3 (see Fig. 13).

This set of spheres was also calcined at 1450°F, and the test was repeated at 2250°F. These spheres all broke diametrally but in increasing time depending upon the content of the silicon carbide (see curve 5, Fig. 14).

FIG. 12.

Effect of Diffusivity on Spalling

Part II of this paper is given merely to show the effect of diffusivity on spalling. A study of the attached curves seems to show that the diffusivity is a definite factor.

The introduction of the greater amount of bond clay in the first set of spheres resulted in a variable of increased strength being introduced. The use of the calcined clay filler overcame this to a large degree.

Several equations have been given to show the resistance to thermal rupture of materials. The oldest and most frequently quoted perhaps is that of Winkelmann and Schott.[3]

$$R = \frac{P\sqrt{k}}{E\alpha\sqrt{\rho\sigma}} = \frac{P\sqrt{\kappa}}{E\alpha}$$

α = coefficient of expansion
κ = thermal diffusivity
P = tensile strength
k = thermal conductivity
ρ = density
σ = specific heat
E = modulus of elasticity

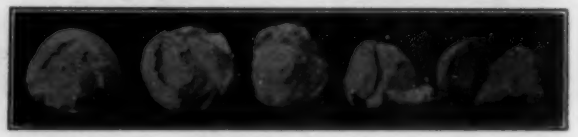

FIG. 13.

This does not seem logical as R would be expressed in degrees times length divided by the square root of time, whereas if diffusivity is dropped the expression is considerably simplified, and R is expressed in degrees. This does not seem just, however, as diffusivity, time, and size are not considered. The following formula is therefore suggested:

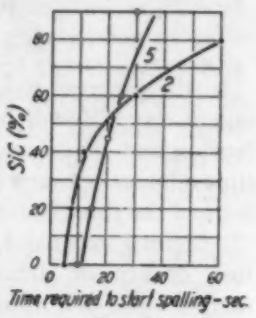

FIG. 14.

$$R = \frac{M}{E\alpha}\left(\frac{\kappa T}{D^2}\right)^{\frac{1}{a}}$$

M = modulus of rupture
E = modulus of elasticity
α = coefficient of linear expansion
κ = thermal diffusivity
T = time
D = diameter
a = constant

In which R is still expressed in degrees.

Hampton,[4] in his work on glass, shows the relation between breaking temperature and thickness. An indication of this was given earlier in Winklemann and Schott.[3] Heindl[5] discusses the effect of the porosity of the specimen; a, in the above equation, may be conceivably as high as 4 for some materials. This is questionable when applied to refractories as it minimizes the effect of diffusivity too much, and 2 is probably more nearly correct.

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[3] *Annalen der Physik und Chemie*, **51**, 730 (1894).
[4] C. E. Gould and W. M. Hampton, "Theoretical Endurance of Glass," *Jour. Soc. Glass Tech.*, **14**, 188 (1930).
[5] See footnote 2.

ZELIENOPLE, PA.

CERAMIC ABSTRACTS[1]

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Vol. 13 **May, 1934** **No. 5**

Abrasives

Polishing Monel metal and pure nickel. Henry R. Power. *Metal Cleaning & Finishing*, **6** [2], 76–77 (1934).—The artificial abrasive, electrically fused aluminum oxide, because of its property of fracturing when it becomes dull thus presenting new sharp cutting edges at all times, possesses ideal characteristics for polishing and buffing Monel metal and nickel. Due to the low thermal conductivity of these metals, a sharp, clean abrasive must be used which will cut with a minimum of pressure and prevent localized heating which would cause discoloration of the piece. E.J.V.

Abrasives. V. L. Eardley-Wilmot. *Mineral Ind.*, **41**, 1–12 (1932).—Sources, output, and fields of use of various abrasive materials are discussed. See also *Ceram. Abs.*, **10** [3], 164 (1931). (*C.A.*)

Measurement of frictional wear of hard surfaces. N. Sawine. *Génie civil*, **103** [11], 254–57; [12], 278–80 (1933).—The Skoda-Sawine apparatus, based on application of the rotating disk, is used. Results of tests on ferrous materials and hard alloys are given. (*B.B.N.F.M.R.A.*)

BOOK

Buffing and Polishing Methods. Lea Mfg. Co., Waterbury, Conn. 56 pp. Reviewed in *Metal Cleaning & Finishing*, **6** [2], 84 (1934).—This handy reference book contains detailed information on finishing. The use of dry abrasive-coated wheels with a flexible surface to replace set-up wheels in finer number is described. E.J.V.

PATENTS

Thread tool grinding machine. John Edgar (Barber-Colman Co.). U. S. 1,947,466, Feb. 20, 1934.

Centerless work feed. Herman Isler (Cincinnati Grinders, Inc.). U. S. 1,948,113, Feb. 20, 1934.

Grinding and polishing device. Erich Poeggel. U. S. 1,948,128, Feb. 20, 1934. C. L. Hawes. U. S. 1,950,030, March 6, 1934.

Abrasive stick holder. S. M. Hershey (Albert P. DeSanno, Sr.). U. S. 1,948,266, Feb. 20, 1934.

Centerless grinding machine. William Ogilvie (B. S. A. Tools, Ltd.). U. S. 1,948,392, Feb. 20, 1934.

Honing machine. J. P. Ferris (Oilgear Co.). U. S. 1,948,468, Feb. 20, 1934.

Abrasive tool. F. E. Bertrand (United Shoe Machinery Corp.). U. S. 1,948,643, Feb. 27, 1934. W. A. Reed (United Shoe Machinery Corp.). U. S. 1,948,674, Feb. 27, 1934.

Grinding machine having motor driven wheel spindle. H. W. Dunbar (Norton Co.). U. S. 1,948,848, Feb. 27, 1934.

Die grinder. E. R. Jones. U. S. 1,948,859, Feb. 27, 1934.

Grinding machine. H. L. Blood (Heald Machine Co.). U. S. 1,948,899, Feb. 27, 1934. W. J. Guild (Heald Machine Co.). U. S. 1,948,914, Feb. 27, 1934. R. A. Heald (Heald Machine Co.). U. S. 1,948,915, Feb. 27, 1934. E. M. Taylor, R. A. Quimby, and R. M. Lippard (Heald Machine Co.). U. S. 1,949,552, March 6, 1934. Henry Perazzoli. U. S. 1,950,264, March 6, 1934. R. N. Heald (Heald Machine Co.). U. S. 1,950,491, March 13, 1934. W. J. Baumberger (Micro Corp.). U. S. 1,950,936, March 13, 1934.

Grinder attachment for brake relining machines. H. B. Barrett. U. S. 1,949,070, Feb. 27, 1934.

Grinding or abrading machine. H. H. Asbridge (Churchill Machine Tool Co., Ltd.). U. S. 1,949,345, Feb. 27, 1934.

Grinding machine table operating mechanism. C. G. Flygare (Norton Co.). U. S. 1,949,511, March 6, 1934.

Lathe for rapidly finishing a rotary work surface. C. H. Norton (Norton Co.). U. S. 1,949,512, March 6, 1934.

Grinding wheel. W. W. Greenwood (Norton Co.). U. S. 1,949,513, March 6, 1934.

Machine and method for lapping ends of round work pieces. F. W. Elstub (Norton Co.). U. S. 1,949,514, March 6, 1934.

Method of turning and grinding round work surfaces. C. H. Norton (Norton Co.). U. S. 1,949,515, March 6, 1934.

Hydraulic wheel feeding mechanism. H. A. Silven (Norton Co.). U. S. 1,949,516, March 6, 1934.

[1] The bold-face number following the journal is the volume, the issue number is in brackets, followed by the page numbers, then the year in parentheses.

Cylinder grinder. M. C. HUTTO (Hutto Engineering Co., Inc.). U. S. 1,950,407, March 13, 1934.

Multiple spindle grinder. E. R. SMITH AND ALBERT SCHINKEZ (Seneca Falls Machine Co.). U. S. 1,950,524, March 13, 1934.

Resin bonded wheel. F. A. UPPER (Bakelite Corp.). U. S. 1,950,641, March 13, 1934. Abrasive article comprises abrasive grains and a binder for the abrasive grains, the binder constituting the essential means for uniting the grains to each other and for imparting regulated strength to the article and comprising a resin of thermally irreversible character and a modifier for the resin of thermally reversible character for effecting a change in toughness of the bond regulated by the ratio of the thermally reversible modifier to the thermally irreversible resin without a change in the total binder content necessary to even distribution of the binder throughout the article and to control of the bonding action.

Dental instrument grinding device. OTTO SUTER. U. S. 1,950,824, March 13, 1934.

Needle-polishing machine. JAMES BAXTER AND WILLIAM TIVENDALE (Singer Manufacturing Co.). U. S. 1,951,232, March 13, 1934.

Abrasive and process of manufacturing. U. M. BINKLEY (Carborundum Co.). U. S. 1,951,233, March 13, 1934. Granular abrasive material is characterized by qualities substantially those of granules crushed from pieces of fused alumina at least three times their resultant diameter in a single crushing.

Cylinder grinding tool. F. B. DEHN (Automotive Maintenance Machinery Co.). Brit. 405,323, Feb. 14, 1934, and Brit. 405,617, Feb. 21, 1934.

Grinding or honing tool for piston pin and like bearings. F. B. DEHN (Automotive Maintenance Machinery Co.). Brit. 405,427, Feb. 14, 1934.

Machines for shaping work pieces by grinding, abrading, or cutting. E. J. CROSS (Dardelet Threadlock Corp.). Brit. 405,480, Feb. 14, 1934.

Abrasive implements. H. V. POTTER AND BAKELITE, LTD. Brit. 405,648, Feb. 21, 1934.

Gaging apparatus for grinding or abrading machines. LANDIS TOOL CO. Brit. 405,817, Feb. 21, 1934.

Abrasive bodies. DEUTSCHE CARBORUNDUM-WERKE G. M. B. H. Ger. 571,868, March 8, 1933. Abrasive powder is suspended in rubber dispersions and hardened. See also Ger. 571,436, *Ceram. Abs.*, **12** [9], 321 (1933). (*C.A.*)

Art and Archeology

Notes on masses suitable for stanniferous enamels. V. LUCAS. *Rev. mat. constr. trav. pub.*, No. 291, pp. 228–31*B* (1933).—A series of experiments made with faience mixes suitable for enamels containing tin oxide is discussed. M.V.K.

Iron sulfide coloring in loam glazes. K. L. LITZOV AND G. BROCKS. *Sprechsaal*, **67** [1], 1–2 (1934).—A series of experiments to determine the effect of sulfide on the coloring of glazes is described. The results are tabulated. M.V.K.

Ceramic colors and coloring. Modern developments in glaze production. CERAMIC CHEMIST. *Chem. Trade Jour.* [London], **93** [2420], 245–46 (1933).—A description is given of (1) blue and purple glazes, (2) chromium and copper greens, (3) yellow and orange glazes, (4) titanium glazes, (5) results of experiments with copper compounds, (6) German patented method for the production of yellow pigments to replace cadmium sulfide, Naples yellow, and sodium uranate, (7) value of titanium dioxide, (8) red, the most difficult glaze color, and (9) a new formula for stoneware glaze (for blue and green tones). M.V.K.

Measurement of colors and its industrial application. RENÉ TOUSSAINT. *Mém. compt. rend. soc. ing. civils France*, **85**, 743–68 (1932). (*C.A.*)

Corrections and changes in the compositions of glazes and enamels for majolica and ceramic ware in general. FAUSTO POZZI. *Corriere Ceram.*, **14**, 135–41 (1933).—The composition and the coefficient of dilatation of 45 glazes and enamels are given. Through qualitative and quantitative changes of the constituents, glazes and enamels with definite coefficients of dilatations are obtained. (*C.A.*)

Lead and antimony contents of simple earthenware glazes of Bukowina. A. SCHMIDT. *Bul. facultatii stiinte Cernauti*, **6**, 216–21 (1933).—Sb was not found in the pottery glazes analyzed, but Pb was present in such amount that dangerously poisonous solutions were obtained when the vessels were used to heat dilute solutions of tartaric, lactic, and acetic acids, such as are found in wine, sour milk, and other foods. The use of Pb-containing materials for pottery glazes is condemned. (*C.A.*)

Metal deposition on glass. OTTO HERFURTH. *Diamant*, **55** [32], 373–74; [33], 388–89; [35], 410–11 (1933).—A detailed description is given of (1) gold plating according to Liebig and Böttger, (2) silver plating according to Liebig, Böttger, and Wood; (3) the methods of Lumière, Bary, and Kaiser, (4) reclaiming silver from residues according to Kundt, Dode, and Vasserot, and (5) copper plating of glass. M.V.K.

Cellulose finishes for pottery. ALBERT E. ROBINSON. *Paint Manuf.*, **3** [5], 125–29 (1933); abstracted in *Sprechsaal*, **66** [48], 819–20 (1933).—Methods for obtaining (1) marble and alabaster effects, (2) bird's-egg speckles, (3) ripple finish, (4) spatter finish, (5) aged ivory finish, (6) limnate finish, and (7) antique finish are described. Illustrated. M.V.K.

Board of ceramic art. ANON. *Zprávy Československ. keram. společnosti*, p. 131 (1932).—A board on ceramic art was founded as a branch of the Czechoslovakian Ceramic Society to study ancient folklore and modern ceramics. R.B.

Mika Mikoun, sculptor ceramist. ANON. *Christian Sci. Mon.*, **26** [88], 5 (1934).—M. designs decorative garden figures and small figures for interior decoration. As a sculptor ceramist, an artist must have (1) training not only in modeling and ceramics, but also in geology and chemistry, (2) training in use of color and the technicalities of glazes, enamels, and pigments, and (3) a knowledge of clays and their uses. E.J.V.

Chintz patterns on china. ANON. *Christian Sci. Mon.*, **26** [34], 5 (1934).—English porcelain sets have the chintz

pattern in the center of the plate with an ivory white border. An American porcelain pattern simulates the Paisley shawl design. E.J.V.

Quimper pottery. ROBERT M. MCBRIDE. *Christian Sci. Mon.*, **26** [51], 7 (1934).—Quimper pottery is Breton faience (Brittany pottery), a heavy earthenware with a high glaze of oddly shaped as well as conventional pieces. Though the design on each article varies, conventionalized flowers, birds, and people being the motifs, each piece harmonizes with the other, for the same general style of design is followed. Blue and yellow are the predominating colors, varied with red, green, and orange. E.J.V.

History of Dutch stoves. DOBROSLAV HAVLÍK. *Stavební rádce*, pp. 45–57 (1933).—At České Budějovice a stove tile with the sign of the stove-fitter's guild dating it between the years 1780 and 1790 has been found. Illustrated. R.B.

Porcelain through the ages. FRANK RUTTER. *Christian Sci. Mon.*, **26** [81], 7 (1934).—One of the most beautiful and valuable collections of china, Oriental and European, is on exhibit at the house of Sir Philip Sassoon, London, England. Over 2000 pieces loaned from private British collections, worth over $3,000,000, are included. Outstanding examples of each type of ware are described in detail. Illustrated. E.J.V.

Oldest civilization of Cyprus revealed. P. DIKAIOS. *Illus. London News*, **183**, 1010 (1930).—A neolithic settlement with pottery has been discovered near Limassol. D. is curator of the Cyprus Museum. 16 photographs. H.H.S.

Egyptian materials and industries about 1350 B.C. A. LUCAS. *Analyst*, **58**, 654–64 (1933).—Faience, glass, stone-working, and other industries of the 18th Dynasty are described from the chemical side. H.H.S.

BOOKS

Contribution to the history of faience production at Bucovice. KAREL ČERNOHORSKÝ. Edited by J. Rokyta. 43 pp., 34 illustrations. At the beginning of the 18th Century Bučovice, Moravia, was an important center of faience (or pseudofaience) production. The babtiste descendant, Jan Langert, who immigrated from Slovakia in 1721, together with Šimon Nikodem from Hvězdice (1722) and Peter Purk (1724), was the first to produce this work. In 1745 there were four shops at Bučovice, one of them belonging to Bernard Šumický, whose descendants continued in this work until 1860. The opinion of Jos. Tvrdý (1910) that babtists lived in Bučovice in the 17th Century can not be maintained. J. Sonntag and G. Bächer (1885) are wrong if they assert that there were twenty-five shops at the beginning of the 18th Century. In 1768 Bučovice was an important center of the industry. In 1797 the village had fourteen masters and apprentices of the art, and these workers produced 15,340 pieces during that year. At the beginning of the 19th Century the number of masters and apprentices was twenty-five, more than at any other place in Moravia. Production rose to 21,500 pieces. During this same year at Vyškov twenty-three men produced 98,000 pieces and at Valaš, Meziříčí, seventeen men made 47,300 pieces. In 1836 production began to fall. Only three painters and eight workmen were employed at Bučovice that year. The last master, Jan Šír from Zdánic, left Bučovice in 1895, probably moving to Slovakia. The oldest known faience product from Bučovice is a mug manufactured in 1726 and now owned by Dušan Jurkovič. R.B.

Mosaics of St. Sophia at Istanbul. THOMAS WHITTEMORE. 28 pp., 21 plates. Oxford Univ. Press for the Byzantine Institute of America, 1933. Reviewed in *Times Lit. Supp.*, **32**, 919 (1933).—A preliminary report on the first year's work by the Byzantine Institute of America is given. See *Ceram. Abs.*, **12** [3], 102 (1933). H.H.S.

Ceramics at the Museum for Art and Industry at Prague. Annual Report, 5 pp., 1932. Large statues of Kändler (Meissen) and old Bohemian porcelain and stoneware have been added to the collection. R.B.

The babtiste "šál" of 1605 in the collection of the Municipal Museum at Ceske Budějovice. KAREL ČERNOHORSKÝ. From the Annual Report, Municipal Museum, Ceske Budějovice, 5 pp., 1926–31.—A rare ceramic dish from the Museum is described. Such white-glazed carved dishes, which were called "sals," had the value of precious metals. They were produced during the years 1598 to 1694 by Czech babtists in the Italian Faenza manner. Illustrated. R.B.

PATENTS

Design for bottle. E. W. FUERST (Fleischmann Distilling Corp.). U. S. 91,520, Feb. 20, 1934. E. W. FUERST (National Distillers Products Corp.). U. S. 91,561, Feb. 20, 1934. W. R. LEACH (Carr-Lowrey Glass Co.). U. S. 91,528, Feb. 20, 1934, and U. S. 91,670, March 6, 1934. C. K. SIMON (Dominion Distilleries, Inc.). U. S. 91,638, Feb. 27, 1934. WILLIAM GUYER (Schenley Products Co., Inc.). U. S. 91,653, March 6, 1934. H. L. LULY (Continental Drug Corp.). U. S. 91,677, March 6, 1934. N. F. STEUER (Owens-Illinois Glass Co.). U. S. 91,691, March 6, 1934, and U. S. 91,740, March 13, 1934. A. M. CLARK (Whitall-Tatum Co.). U. S. 91,704, March 13, 1934. E. W. HOWE (Owens-Illinois Glass Co.). U. S. 91,712, March 13, 1934.

Design for plate. YUKIO BUMA (Morimura Bros., Inc.). U. S. 91,602, Feb. 27, 1934. R. L. MARWEDE (Rosenthal China Corp.). U. S. 91,633, Feb. 27, 1934. JOHN BERGNER (Trenle China Co.). U. S. 91,643, March 6, 1934.

Design for perfume bottle and base ensemble. MARTIN DE BOTELHO. U. S. 91,609, Feb. 27, 1934.

Design for casserole, bowl, etc. L. E. HELLMANN (Continental Ceramics Corp.). U. S. 91,623, Feb. 27, 1934.

Design for dish. L. E. HELLMANN (Continental Ceramics Corp.). U. S. 91,624, Feb. 27, 1934.

Design for pitcher. L. E. HELLMANN (Continental Ceramics Corp.). U. S. 91,625, Feb. 27, 1934.

Design for water-closet bowl. W. C. GROENIGER. U. S. 91,696, March 6, 1934.

Hardening and waterproofing compound for cement and concrete mixtures. R. E. A. DE BOW (Acqua-Pruf, Inc.). U. S. 1,951,186, March 13, 1934. A cement composition comprises a cement mixture including calcium chloride, amorphous silica, sodium silicate, and impalpable fillers suspended in an aqueous tannin solution.

Cements

Presence of silt and clay in sands used in cement mortars. D. G. R. Bonnell. *Jour. Soc. Chem. Ind.* [London], **53** [8], 54–57*T* (1934).—B. describes two methods for determining the amount of clay present in sand used for aggregate in cement mortars. A diagram of the apparatus is shown and detailed directions for making the tests are given. Tests were made to determine the influence of the clay on the strength of cement mortars. The results indicate that up to about 7% of clay reduces the tensile strength about 15 to 25% of the strength attained with the clean sand. A clay content of 13% is necessary to give reductions in strength of 50%. A.J.M.

Comparison of magmatic and nonmagmatic silicate systems. Leo Koch. *Centr. Mineral. Geol.*, **A**, 219–23 (1933).—Slags from various anthracite coals all contain well-crystallized basic plagioclases as the chief component. Pyroxenes (hedenbergite-diopside) and magnetite also occur frequently. These slags are closer in mineralogical composition to feldspathic basalt than any previously reported. Further examination of slags should aid in the study of magmatic differentiation. (*C.A.*)

Portland cement rich in magnesia. Hans Kühl and Ernst Ludwig Meyer. *Tonind.-Ztg.*, **58** [1], 6–8; [3], 27–29; [4], 40–42 (1934).—All observations show that it is possible to produce volume stable, sintered cements rich in magnesia of the Portland type. M.V.K.

Enamels

Report of preliminary investigation of thermal properties of porcelain-enameled steel. Anon. *Enamelist*, **11** [5], 11–12 (1934).—A detailed description of comparative tests of the insulating value of porcelain-enameled steel and Insulite is presented. Results show that the enameled sheets are about half as good as $^1/_2$ in. of Insulite as protection from radiant heat. The thickness of the enamel coat seems relatively unimportant, probably because of the layer of bound air next to the test sheet; advantage should be taken of the layer of bound air by trying the effect of two enameled sheets placed close together with only a thin space (about $^1/_8$ in.) between. E.J.V.

Investigations and observations on the strength of cast iron. J. E. Hurst. *Metallurgia*, **8** [48], 179–80; **9** [49], 17–18; [50], 43–45 (1933).—To promote greater uniformity in regard to strength properties of cast iron, H. discusses methods of determining the stress-strain relation, the value of modulus of elasticity, and its relation to the chemical composition of cast iron. Factors which contribute to structural differences in cast iron in relation to the modulus of elasticity are discussed, and the results of experimental work are given. M.V.K.

Oxygen in cast iron. W. F. Chubb. *Metallurgia*, **9** [50], 53–54 (1933).—The deoxidation of cast iron and the effect of various deoxidizing agents such as aluminum, titanium, vanadium and zirconium, and bismuth and boron are discussed. See also *Ceram. Abs.*, **13** [1], 5 (1934). M.V.K.

Influence of chemical composition on enameling properties of cast iron. P. Eyer. *Emailletech. Monatsblätter*, **14** (Feb., 1932); *Met. Abs.* (in *Metals & Alloys*), **4**, 163 (1932).—S is particularly detrimental to the enameling properties of cast Fe in that the segregations of Fe sulfide and Mn sulfide render difficult the adherence of the enamel to the surface. The dangerous effect of S can be decreased by a sufficiently high amount of Mn. Too high an amount of P increases the brittleness so that the Fe tends to the formation of cracks on being enameled. The P content should not exceed 0.9%. The Si content should amount to at least 2.2%. With a Si content above 2.6% a coarse separation of graphite and an increased tendency to growing may be apparent. This also may be detrimental to enameling. (*C.A.*)

Discussion of tests for porcelain enamel applied on sheet and cast iron. H. D. McLaren. *Jour. Can. Ceram. Soc.*, **2**, 38 (1933).—M. discusses methods employed in different laboratories for testing porcelain enamel coatings with regard to their durability under various stresses. J.G.P.

Milling sheet-iron ground coat with 40 to 45% water and adding water in the dipping tank *vs.* milling the frit with a greater amount of water. Frank Porter, A. H. Haessler, and C. D. Parkhill. *Enamelist*, **11** [5], 18 (1934).—The consensus of opinion of the men answering this question is to mill the frit with a greater amount of water rather than to add water to the dipping tank. Each gives reasons for his opinion. E.J.V.

Barium nitrate in the production of enamels and glazes. Thoma G. Grote. *Glashütte*, **63** [29], 492–94; [30], 507–508 (1933); abstracted in *Emailwaren-Ind.*, **11** [1], 7 (1934).—Barium nitrate replaces alkali nitrates as far as the action of the nitrate is concerned; it attacks the melting vessels much less, being a weaker base. One part of alkali can be replaced by barium without injuring the fusibility; more stable and better enamels are obtained and the colors are purer. Experiments were made with frits in which potash was replaced by barium nitrate; it was found that a part of minium can also be replaced. Barium carbonate does not yield sufficiently fusible frits. M.V.K.

Introduction of copper oxide in low-melting ceramic fluxes. R. Rieke and H. Steinbock. *Ber. deut. keram. Ges.*, **14** [12], 547–62 (1933).—The effect of copper oxide on the fusibility, viscosity, devitrification tendency, and thermal expansion of low-melting ceramic fluxes which consisted of PbO, Na_2O, SiO_2, and B_2O_3 was determined, as well as the relation of the color produced by the CuO to the composition. The most important results were as follows: The replacement of a small amount of PbO by CuO decreases the thermal expansion, increases the fusibility, and reduces the tendency toward devitrification; larger amounts of CuO have an opposite effect. The viscosity of the melt and the change in viscosity with temperature are decreased by CuO. The fluxes studied absorb up to 12% CuO; a higher addition results in throwing out crystalline CuO. The green color produced by CuO gradually changes to blue with the introduction of increasing amounts of

Na_2O. The blue color is not injured by a PbO content up to 37%, but it is deepened by 6 to 11% B_2O_3. The fluxes colored blue by CuO show a high thermal expansion and low chemical resistivity due to their high sodium content. It would be possible to improve the fluxes in these directions by increasing the degree of acidity. E.J.V.

Ground-coat studies. VI. Restoration of lost set. E. P. Czolgos. *Better Enameling*, **5** [2], 20–22 (1934).—The common methods of restoring set to ground-coat enamel include addition of a fresh ground-coat enamel slip and of electrolytes, "blunging" with electrolyte addition, and addition of sodium aluminate. Tests were made on the various methods. Results showed that the addition of sodium aluminate to the initial mill charge did not improve the consistency of the enamel slip but, when used to restore set to the ground-coat enamel slip by means of "blunging," it gave excellent results and produced enamel slip possessing consistency properties approaching a condition of stabilization. It is suggested as a method worthy of consideration for restoring set to ground-coat enamels. For Part V see *Ceram. Abs.*, **13** [4], 80 (1934). E.J.V.

Opacity of cover-coat enamels. L. C. Athy. *Jour. Can. Ceram. Soc.*, **2**, 46 (1933).—With an electric spectrophotometer much valuable information can be obtained on the factors affecting the opacity of cover-coat enamels. The major problems pertaining to white cover-coat enamel opacity are covered, with a few remarks regarding black oxides. J.G.P.

Coloring oxides. Kenneth M. Hossack. *Jour. Can. Ceram. Soc.*, **2**, 55 (1933).—Coloring oxides are discussed and a method of matching colors is described. J.G.P.

Test for blast sands. L. H. Cole. *Jour. Can. Ceram. Soc.*, **2**, 58 (1933).—The pebble-jar grinding test can be safely used to determine whether a sand is good, medium, or poor, but can not be used to differentiate between two good sands, two medium sands, or two poor sands. J.G.P.

Acid-resistant metals used in cleaning steel. W. I. Sivitz. *Metal Cleaning & Finishing*, **6** [2], 73–75 (1934).—Alloys which resist the corrosive effects of pickling acids and recent improvements in equipment to facilitate acid handling and pickling operations are discussed. Illustrated. E.J.V.

Pickling iron and steel. William Ashcroft. *Metallurgia*, **9** [49], 19–20 (1933).—Pickling is a process in which so many controlling factors are involved that proper results can be obtained only when the conditions have been standardized for the particular base metal to be treated. Of these, the temperature and strength of the acid bath are most important. M.V.K.

Deënameling sheet-iron shapes. S. W. Vickery. *Jour. Can. Ceram. Soc.*, **2**, 47 (1933).—Various methods of deënameling are discussed. V. states that caustic soda for deënameling is becoming more necessary with the increasing use of acid-resisting enamels. J.G.P.

Discolorations in enamels. Anon. *Glashütte*, **63** [35], 592–93 (1933); abstracted in *Emailwaren-Ind.*, **11** [1], 7 (1934).—The effects of (1) grinding, (2) conditions of firing, (3) composition of the enamel, and (4) cooling of the fired enamel on the color tones of the enamel are discussed in detail. M.V.K.

Notes on the discussion of L. Vielhaber on cracked cooking utensils. A. Dietzel. *Emailwaren-Ind.*, **11** [1], 1–5 (1934).—The fact that kaolin when used as opacifier produces an enamel of poor quality is analogous to phenomena occurring in glass technique. Melted glass, in contact with refractories (grog of tank blocks) for a long time, dissolves large quantities of grog, *e.g.*, at 1400°, 100 g. of glass may dissolve up to 400 g. grog. Enamel contains much greater quantities of ingredients dissolving kaolin than glass and the surface of attack of the finely granulated kaolin is much larger than in dense grog blocks, although the temperatures used in enameling are lower and the dissolving occurs only for several minutes. Kaolin is more easily dissolved than grog, hence the enamel, when fired, dissolves large amounts of kaolin which do not opacify. During the dissolving, kaolin disintegrates and its ingredients form various components in the enamel. The dissolved kaolin basically changes the properties of the enamel, especially its expansion, and the enamel is no longer adapted to the ground (or iron). Alumina (introduced in the form of kaolin or feldspar) makes the enamel viscous and produces inhomogeneities (knobs, streaks, and undissolved particles) which give poor mechanical and thermal properties. These conditions do not appear with tin oxide. Little of it is used for opacification; it is only slightly dissolved in the enamel during firing and because of this does not change the enamel properties a great deal. Large amounts of undissolved kaolin do not produce faults in enamels opacified with it, but the high solubility of kaolin in the enamel brings about an abnormal change in the enamel composition and probably produces an inhomogeneous enamel. For article by Vielhaber see *Ceram. Abs.*, **13** [2], 33 (1934). M.V.K.

Poisonous action of enamel and of enameled ware. R. Aldinger. *Glashütte*, **63** [37], 617–19 (1933); abstracted in *Emailwaren-Ind.*, **11** [1], 7 (1934).—The sources of danger to the health of workers in enamel works are depicted in detail; they are based on the poisonous action of some raw materials employed and on the injurious effects of dust. Enamels designed for eating, drinking, and cooking purposes must not give off poisonous materials such as lead, trivalent antimony, etc., when used. Attempts to lower the lead content of majolica enamels are discussed. M.V.K.

Enameling and bright annealing furnaces. Continental Industrial Engineers, Inc. *Fuels & Fur.*, **12** [1], 35 (1934).—This enameling furnace is provided with a special type of silicon carbide muffle arranged to give rapid uniform heating and long life and is heated with city gas by the use of a Maxon premix unit. There are no fumes, visible flames, smoke, dirt, noise, or external heat associated with the operation of the furnace. E.J.V.

Acid-proof enamels in chemical technique. Ludwig Stuckert. *Chem. Fabrik*, pp. 245–48 (1933).—Properties, composition, and manufacture are discussed. See also *Ceram. Abs.*, **12** [12], 415 (1933). (*C.A.*)

Late developments in the enameling industry. Emerson P. Poste. *Ceram. Ind.*, **22** [3], 138–45 (1934).—Literature covering the recent technical advances in enameling is reviewed and the effect of these developments is interpreted. X-ray methods in the study of enamels, tensile strength and elasticity, enamel adherence, gaseous defects in enamels, and the composition of enamels are discussed. E.J.V.

Progressive retailer makes use of porcelain enamel. H. C. AHRENS. *Better Enameling*, 5 [2], 18–19 (1934).—A salesroom in Louisville, Ky., is paneled with porcelain enamel to a height of 7 ft. in cream with jade green decorated pilasters and cornices. Illustrated. E.J.V.

Chain food stores prefer porcelain enamel. HARRY E. MARTIN. *Enamelist*, 11 [5], 22 (1934).—Reasons for this choice are cleanliness, beauty, maximum benefits from lighting, and economy and utility of porcelain-enameled fixtures. Illustrated. E.J.V.

PATENTS

Production of opaque glasses and enamels. IGNAZ KREIDL. U. S. 1,948,461, Feb. 20, 1934. An improved process of producing white clouded enamels for ironware, etc., consists in adding to the enamel frit while grinding it in the presence of water, in lieu of the known white insoluble oxides heretofore used as the clouding media, substances which, in unchanged condition, are incapable of serving as clouding agents, but which, upon firing of enamel, evolve gases which remain in the enamel at the firing thereof, together with a clay which is capable of adsorbing strongly the gas-evolving substances, and controlling the size, number, and subdivision of the gas bubbles evolved in the enamel on firing by altering, prior to firing, the amount of the clay used.

Vitreous enamels and process of making. C. J. KINZIE AND C. H. COMMONS, JR. (Titanium Alloy Mfg. Co.). U. S. 1,949,479, March 6, 1934. The process produces an opaque frit for vitreous enamels resistant to acids and comprises mixing a raw batch of enameling materials substantially in the following proportions in parts by weight: sodium zirconium silicate 7.08, quartz 40.58, borax 18.94, soda ash 19.65, sodium nitrate 3.50, titanium oxide 13.86, red lead 3.04, antimony oxide 6.93, and fluorspar 5.94, and then heating the raw batch so mixed to fusion and formation of the opaque enamel frit.

Conveyer system for handling washing machine tubs during enameling process. C. G. CHALLNOR (Colonial Iron Works Co.). U. S. 1,949,991, March 6, 1934.

Enameling kiln. CARL THIEL. Ger. 582,474, Aug. 15, 1933. (*C.A.*)

Glass

Some new glasses containing bismuth. E. RAYMOND RIEGEL AND DONALD E. SHARP. *Jour. Amer. Ceram. Soc.*, 17 [4], 88–92 (1934).

Leakage of helium through Pyrex brand glass at room temperature. I. GREGORY P. BAXTER, H. W. STARKWEATHER, AND R. B. ELLESTAD. *Science*, 68, 516–17 (1928).—Leakage of He through Pyrex brand glass at 0° and atmospheric pressure was noted in 24 hr. in change of PV with P experiments. Mechanical leakage was eliminated by comparative experiments with He at 770 mm. and at 627 mm. showing a like change per day in either case of about 0.0031%, corresponding to 0.04 cu. mm.[3] per day per sq. cm.[2] The apparatus had previously showed no similar effect with A. These results were confirmed by comparing a spherical Pyrex brand glass globe filled with He with a counterpoise of a larger globe containing A for a year. The loss in weight per day gradually fell off as follows: 0.02 mg. the first day, 0.007 the eighteenth, 0.006 the thirty-fourth, and decreased gradually from 0.0059 to 0.0047 between the seventy-first and the three hundred sixty-sixth days. The total loss was 1.73 mg. He (1%) corresponding to an average of 0.059 cu. mm.[3] per day per sq. cm.[2] of Pyrex brand glass averaging 1.34 mm. in thickness. The determinations by B. and S. of the density of He carried out in Pyrex are not affected. **II.** G. P. BAXTER AND H. W. STARKWEATHER. *Ibid.*, 73, 618 (1931).—The loss from a globe containing 1044 cc. has amounted to nearly 3.5% since Nov. 11, 1927. See also *Chem. Abs.*, 19, 1643; 20, 1006; 21, 1728. (*C.A.*)

Permeability of quartz and Pyrex brand and other glass to helium. J. C. MCLENNAN AND J. O. WILHELM. *Trans. Roy. Soc. Can.* [Section III], 26, 119–22 (1932).—Experiments showed that He penetrates quartz and Pyrex brand glass, the rate of penetration increasing with the temperature. Evacuated, outgassed, and sealed quartz tubes were placed in an atmosphere of He until the desired pressure of He inside the tubes was reached when they were removed from the He bath and used as He discharge tubes. (*C.A.*)

Investigation of thermal expansion of the double system $Na_2B_4O_7$—B_2O_3 in molten state. M. P. VOLAROVICH. *Bull. acad. sci. U.R.S.S., Classe sci. math. nat.*, pp. 663–74 (1933).—The dilatometric method was used for measuring the specific volume of molten glass up to 1300° and consisted in measuring the level of the molten glass, contained in a test-tube shaped Pt vessel, by means of electric contact with a Pt rod. Specific volumes of $Na_2B_4O_7$, B_2O_3, and of binary mixtures containing 74, 59.5, and 20% $Na_2B_4O_7$ were measured through the interval 500 to 1300°. The expansion coefficients obtained are in satisfactory agreement with those of Samsoen. With B_2O_3, the expansion coefficient reaches a maximum at about the melting point, then gradually decreases. Results confirm Batschinski's formula, $v = \omega + (c/\eta)$, where η = viscosity, v = specific volume, and c and ω are constants for a certain range of temperature. At high temperatures, the relation between $1/\eta$ and v is linear. At lower temperatures variation from linearity is considerable, which can be accounted for by polymerization. Isothermal curves for v plotted against percentage composition show that mixing $Na_2B_4O_7$ with Na_2B_2 is accompanied by considerable contraction with eventual increase in viscosity. (*C.A.*)

Quick method for determination of alkali in glass. E. V. VASIL'EVA. *Zavodskaya Lab.*, No. 2, pp. 25–26 (1933).—The $Na_2C_2O_4$ formed by the action of $H_2C_2O_4 + H_2F_2$ is ignited to Na_2CO_3 and titrated with HCl or dry $Ca(OH)_2$ is added and the CaC_2O_4 ignited to $CaCO_3$, extracted, and titrated with HCl. (*C.A.*)

Autoclave method. A simple scientific test for measuring resistance of glass to chemically active products. WROE ALDERSON AND B. B. AIKEN. *Glass Packer*, 12, 165–66 (1933).—Bottles filled with distilled water are auto-

claved for 6 hr. at 35 lb. pressure (approximately 280°F). The contents are removed, rinsed out, and titrated with standard NaOH with methyl red as indicator. Results are reported as grams of NaOH per liter. (*C.A.*)

Supersaturation of gases in glass. J. Loeffler. *Ceram. Ind.*, **22** [3], 156–58 (1934).—A comprehensive review of the work of scientists on the presence of gases in glass, methods of purification, composition of the gases, and means of determining whether the gases are held in chemical combination in the glass is presented. E.J.V.

Glasses absorbing ultra-violet rays and transmitting heat. Anon. *Glas & App.*, **14** [6], 43–44 (1933).—Glasses with this property are made with mixtures of oxides of cerium; these also absorb heat rays but only to a limited extent. The following mix is given: *e.g.*, 71% SiO_2, 16Na_2O, 8CaO, 2.3 cerium oxide, 1.8 lanthanum oxide, 0.8 didymium oxide, and 0.1 yttrium earths. M.H.

Comparison tests with alumina and feldspar as alumina containing materials in glass. Fr. Stang. *Glashütte*, **63** [37], 615–16 (1933).—Conclusions are as follows: (1) Hydrate of alumina has the same or a somewhat higher capability of melting in comparison with feldspar when the soda content is introduced from sodium carbonate. (2) Feldspar has an advantage over alumina as to capability of melting in all cases in which the sodium content is obtained from sulfate. (3) When the sodium content is obtained from both soda and sulfate, the advantage of one of these factors depends on the proportion of their mixtures. (4) Hydrates of alumina and feldspar are more fusible than alumina (oxide); hydrate of alumina is more advantageous than feldspar because of a more uniform composition. (5) Because of its greater purity, hydrate of alumina yields a finer tinge in the finished glass. M.V.K.

Notes on the manufacture of colorless glasses. No. 24. Thermal endurance. Anon. *Glass*, **11** [2], 61–65 (1934).—The relationship of the coefficients of expansion of the constituent oxides to the thermal resistance of the final product is explained. Factors of cubical expansion for the common glass-forming oxides are given. For No. 23 see *Ceram. Abs.*, **13** [4], 84 (1934). A.J.M.

Theoretical bases of glass coloring. W. Weyl. Presented at meeting of German Glass Technical Society, 1933; *Keram. Rund.*, **41** [15], 188 (1933).—The elementary processes of the absorption of light and the appearance of an absorption spectrum are discussed. An exact quantitative understanding of spectral absorption permits the investigation of the oxidation equilibriums of oxides forming glass. It was possible, for the first time, to show that chromic compounds and chromates are present in chrome glasses, to give quantitative data, and to produce a pure blue-green chromic and lemon-yellow chromate glass. On the basis of analogies with solutions and crystallized compounds, it is possible to obtain a knowledge of the constitution and color of cobalt and nickel glasses. The color of cobalt glass depends on the number of "ligands" with which the Co atom is combined and less on its chemical nature. Hence the formation of blue and red cobalt glasses can be understood and the dependence of color on temperature and heat treatment is explained. M.V.K.

Particle size and concentration in opal-diffusing glasses. C. Dunbar. *Jour. Soc. Glass Tech.*, **17** [68], 411–32 (1933).—The average particle size and concentration in a number of opal glasses were determined by means of a high-power microscope, and the way in which these quantities vary through the thickness of a glass was investigated. The diffusing properties of the glasses were measured photometrically and the average size and concentration of the particles in the glasses were deduced from the theoretical equations of Ryde and Cooper (*Ceram. Abs.*, **12** [7], 256 (1933)). A comparison has been made of the theoretical and experimental results, and it is shown that over the range of particle size considered, the theory is in good agreement with experiments. See also *ibid.*, **12** [4], 147 (1933). A.J.M.

Manganous oxide as glass component. I. I. Kitaigorodskiĭ and N. W. Solomin. *Sprechsaal*, **67** [2], 18–20; [3], 29–31 (1934).—Colorless or faintly colored glasses may be manufactured with a considerable content (20%) of manganous oxide. Manganous oxide lowers the viscosity of soda-lime-silica glasses of the composition 17% Na_2O, 10.5 CaO, 72.5 SiO_2; hence the alkali content may be partly replaced by manganous oxide. The softening temperature of such glasses is lowered with the introduction of manganous oxide. It increases the specific gravity of ordinary soda-lime-silica glasses. The specific gravity of MnO amounts to 4.65 and its expansion constant amounts to 3.18 in the glass series studied. Illustrated. M.V.K.

Glass, its manufacture and development for railroad and other uses. J. C. Hostetter. *Proc. Central Ry. Club Buffalo*, **28**, 3213–22 (1930).—An address dealing with the composition, properties, and melting and manufacturing processes of glass. (*C.A.*)

New heat-insulating materials. A. Lindsay Forster. *Mech. World*, **93** [2421], 504–506 (1933).—The properties of glass and aluminium as heat insulators are discussed. Aluminium foil in parallel or concentric sheets insulates by combining the low conductivity of air spaces between the foils and the heat-reflecting power of the bright metal surface. Glass in the form of fine fibers has this heat-reflecting property and is particularly useful where both heat and sound insulation are desired. A new method of testing is described. Illustrated. E.J.V.

Is Sekurit glass a case-hardened product? C. Z. *Diamant*, **54**, 244 (1932).—The question is debated not on controversial grounds but as a matter of scientific interest. Tables are given showing the results of impact tests carried out on case-hardened and ordinary glasses of various thicknesses. The former show a power of resistance four to five times greater than that of the latter. (*J.S.G.T.*)

Light permeability and color tone of building and illuminating glass. H. Craemer. *Glashütte*, **63** [37], 616–17 (1933).—The greenish coloring of glass used for illuminating and building purposes is due to the presence of metallic oxides, especially of ferric and ferrous oxides in the glass melt. This green coloring means a loss of light because only the green colors pass through the glass unweakened, while all the other colors of the spectrum are partly absorbed and destroyed. The physical decoloration of glass or an addition of complementary pigments lowers the total permeability of the glass. Only by means of the chemical decoloration of the glass is the green tinge removed. Experiments showed that cerium and manganese are especially good decolorizers. See also *Ceram. Abs.*, **12** [2], 54 (1933). M.V.K.

Illuminating glassware production. WEBB'S CRYSTAL GLASS CO. *Elec. Rev.*, **114** [2933], 185–86 (1934).—The making and testing of Duroglass illuminating equipment is described. The furnace is made of sillimanite and the crucibles of fire clay. The furnace is oil fired. All globes and shades are hand blown. Satin finishes are secured by acid pickling and frosted finishes by sandblasting. Illustrated. J.L.G.

Studies on chilled plate glass. II. T. ARAKI, S. TAKAHASHI, AND S. MORI. *Jour. Soc. Chem. Ind.* [Japan], **37** [1], 33*B* (1934).—The results are shown in tables. For Part I see *Ceram. Abs.*, **13** [4], 85 (1934). M.V.K.

Progress in hardening glass plates, etc. ANON. *Glass & App.*, **14** [7], 51 (1933). M.H.

Manufacturing glass filters. M. F. LIFSHITZ AND B. L. GUSHMAN. *Keram. i Steklo*, **9** [9], 4–5 (1933).—A detailed description is given of the basic operations for obtaining glass filters, such as (1) grinding glass into powder, (2) sifting the glass powders, (3) fusing the powder into filter plates, (4) soldering the plates into glass apparatus, and (5) controlling the filters. Four kinds of filters with a pore diameter of 120 to 10 microns are manufactured in the U.S.S.R. M.V.K.

Deterioration of certain medicaments under the influence of light. H. V. ARNY, ABRAHAM TAUB, AND ABRAHAM STEINBERG. *Jour. Amer. Pharm. Assn.*, **20**, 1014–23, 1153–58 (1931).—This investigation was planned for glass containers available on the American market but it included six light filters. The quantitative transmission of light (in the visible spectrum) was determined by the spectrophotometer, with white light as the source. The transmission values in the ultra-violet region were determined by the Hilger quartz spectrograph with a sector photometer. To secure comparative thicknesses of glass, representative pieces were cut from the containers and ground flat. The containers were grouped in eight classes: flint A, blue A, green A, green B, green C, amber A, amber B, and amber C. Red flashed glass and Corning red are the best protective glasses studied, but the cost is too high for commercial bottle making. Thirty-five light sensitive chemicals and pharmaceuticals were studied. The findings are tabulated and can not in general be abstracted. From three to twelve times as much deterioration occurred in direct light as compared with diffused. The effects of a number of reputed stabilizers were observed. None gave satisfactory results except that Sn compounds stabilize C_6H_5OH and acetanilide stabilizes H_2O_2 (both known) and $SnCl_2$ preserves H_2O_2 (new). (*C.A.*)

Studies with light rays (in glass-packed products). H. V. ARNY. *Glass Packer*, **12**, 497–99 (1933).—About 15% of chemicals or pharmaceuticals stored in glass containers are truly light sensitive. Amber glass gave by far the best protection from ultra-violet rays. (*C.A.*)

Viscosity measurements of technical glasses and their significance for economy in machine shaping. W. MÜLLENSIEFEN AND K. ENDELL. *Glastech. Ber.*, **11** [5], 161–70 (1933); abstracted in *Keram. Rund.*, **41** [15], 187–88 (1933).—A new ball drawing viscosimeter for determining the course of viscosity of technical glasses in dependence on temperature and chemical composition is described. Viscosity measurements made with this apparatus on hand-, semi-, and fully-automatic white hollow and pressed glasses, cast plate glass, and drawn sheet glasses are described. It was found that glasses of totally different compositions whose working temperatures are far apart always show approximately the same working viscosity of 1000 poises. The significance of these viscosity measurements for economy in glasses produced mechanically according to the Fourcault method is discussed. A literature index is given. M.V.K.

To cool or not to cool? EDITORIAL. *Glas & App.*, **13** [26], 203–204 (1932).—Failures and defects in the manufacture of instruments and apparatus are discussed. M.H.

Czechoslovakian standards for laboratory glassware. OTAKAR WEBR. *Chem. Listy*, **26**, 120–24 (1932); **27**, 108–11, 132–34 (1933).—Shapes, sizes, and specifications adopted by a commission for volumetric, Kohlrausch, Stohman, Stift, and viscometer flasks, graduated cylinders, pipettes, and burettes are given, together with the degree of precision with which the calibration is carried out. Specifications for test tubes, cover glasses, funnels, separatory funnels, Liebig condensers, suction flasks, desiccators, Kipp generators, stopcocks, and wash bottles are also given. (*C.A.*)

Apparatus glass. I–II. F. H. ZSCHACKE. *Chem.-Ztg.*, **57**, 521–23, 542–44 (1933).—The uses and limitations of glass and quartz glass in apparatus construction are discussed. The most valuable properties discussed are (1) transparency, (2) chemical resistance, (3) mechanical hardness, (4) availability, (5) low thermal coefficient of expansion, (6) high heat conductivity, (7) high stability toward temperature shocks, (8) high resistance to mechanical wear and tear, and (9) high softening temperature. Analyses of 12 high-grade glasses are given. The influences of chemical composition and manufacturing processes upon the properties are treated. (*C.A.*)

Manufacture of surgical glassware in the new Italy. JUSTUS HORN. *Glas & App.*, **15** [2], 11–12 (1934).—The development of Italian manufacture of sanitary and medical glassware and its effects on import, especially from Germany, are discussed. M.H.

Glasses of rare earths. FRITZ HANSEN. *Glas & App.*, **14** [6], 43 (1933).—Glasses made from rare earths absorb part of the light so that differences in color become more pronounced if seen through such glasses. At present neodymium and praseodymium are used; their use in the imitation of gems is particularly interesting. The investigations are continued. M.H.

Calibrated and standardized measuring and mixing cylinders. FRITZ FRIEDRICHS. *Glas & App.*, **14** [2], 9–11; [3], 17–19 (1933).—Advantages of unification in shapes of measuring glasses are discussed, and the respective practices of the Bureau of Standards and Physikalisch Technische Reichsanstalt are compared in a table. **Pipettes.** *Ibid.*, **14** [4], 25–26; [5], 33–34 (1933). **Burettes.** *Ibid.*, **14** [6], 41–42; [8], 57–58 (1933).—Standardization of divis ons and errors are discussed. See also *Ceram. Abs.*, **12** [9], 327 (1933). M.H.

Stony glass. LUDWIG SPRINGER. *Glashütte*, **63** [45], 742 (1933).—The classification of glass stones according to their appearance is not easy. There are (1) batch or melt stones and gall stones, (2) grog or Dinas crown stones, and (3) devitrification stones. The appearance of the first

group of stones is caused by (*a*) the batch being too hard, (*b*) coarse-grained material, especially sand, (*c*) bad mixing, and (*d*) low melting temperature. Glass stones are due to undisintegrated Glauber salt. The second main group, that of grog or crown stones, is caused by irregularly melted or broken pot and brick material or drops from the crown. Devitrification stones come from separations in the glass when the batch is wrongly adjusted, the melting is badly conducted, or the temperature of working is too low; such stones may also be formed when the finished melted glass is kept at a low temperature for a long time. Batch stones are mostly colorless, surrounded by bubbles, and show devitrification at their edges. Glass stones are dull, of elliptic form, and have a net-shaped structure. Grog stones are mostly yellow to brown, are more or less nontransparent, show rare crystal formations, but often have cracks in the glass. Devitrification stones are dull, white, and have a radial structure. M.V.K.

Methods for investigating stones and knobs in glass. A. Dietzel. *Sprechsaal*, **66** [49], 837–39; [50], 853–56; [51], 867–69 (1933).—After a brief review of different kinds of stones and knobs and their origin, D. discusses in detail the chief methods employed for their identification including (1) preliminary investigation with a magnifying glass or microscope, (2) chemical preliminary investigation (soda test), (3) preparation of micro-preparations, (4) determination of optical constants of crystals, stones, and knobs, (5) apparent and true axial angle, character of double refraction, (6) calculation of the double refraction, (7) determination of indices of refraction, (8) indentification of crystals on the basis of their optical constants, (9) detection of the kind of stones and knobs from the results of the crystal determination, (10) hints for determining the material forming knobs or streaks by means of the determination of the refractive indices of glass knobs (streaks), (11) inferences from the observation of double refraction (stress) in the surroundings of stones, drops, and streaks, (12) utilization of the heating microscope for investigating stones, (13) valuating analysis samples after microscopic researches, (14) example of the determination of the alumina content of a tank block from the analysis of stones in glass, (15) other examples for the valuation of results of analysis, (16) physicochemical investigation. Illustrated. M.V.K.

Significance of the microscope for judging devitrification. Hugo Kühl. *Glashütte*, **63** [34], 567–71 (1933).—After describing crystals and their formation, K. discusses devitrification. The crystallization phenomena with reference to devitrification are due to different causes. When batches are melted which do not produce eutectic melts, (1) undissolved particles remain in the melt; (2) the glass appears to have streaks and is cloudy and the microscope shows the presence of cristobalite crystals; (3) a part of the melted batch is clear, while the other is cloudy, forming an inhomogeneous glass. On cooling, such a melt devitrifies. An unsuitable firing promotes devitrification. Microscopic investigation of stones often shows the presence of dense crystal needles of prismatic form. They are formed from calcium and silica and are known as wollastonite. Usually wollastonite crystals appear with those of cristobalite. In defective alumina glasses, sodium aluminate crystals form large colorless prisms. The observations of Tammann, Zsigmondy, Jebsen-Marwedel, and Fenner on the formation of crystals are discussed. Illustrated. M.V.K.

Experiences in fine-grinding and polishing glass. Friedrich Huth. *Glas & App.*, **13** [25], 197 (1932).—The tenchique and equipment are described. Coarse grinding should be done to such extent that no more is taken off in fine grinding. Both mechanical and chemical action play important parts. Polishing should be started with high pressure and finished with low pressure. The use of too much polishing agent can spoil the surface. Elevated temperature influences the polishing process favorably. How much the felt contributes is not yet known; the optical industry prefers fine-haired felts, while other industries use coarser-haired felts. Iron oxide is used chiefly with or without iron sulfate. In wet polishing water exerts a chemical influence while dry polishing is purely mechanical. M.H.

Manufacturing glass for electric bulbs in tank furnaces. B. V. Khovanskiĭ, A. I. Morozov, and A. N. Nagornuĭ. *Keram. i Steklo*, **9** [10], 8–11 (1933).—Conditions required for manufacturing glass for electric bulbs in tank furnaces of the Simplex type are discussed. See also *Ceram. Abs.*, **12** [6], 220 (1933). M.V.K.

Bottles manufactured by machinery or hand. A. Jaeschke. *Glashütte*, **63** [29], 479 (1933); abstracted in *Keram. i Steklo*, **9** [10], 28 (1933).—A short review is given of different machines employed for manufacturing glass bottles and the advantages of a machine-made bottle over a hand-made bottle are listed. M.V.K.

Altering the shape of tank blocks for obtaining a greater efficiency in water and air cooling. L. N. Shekhirov. *Keram. i Steklo*, **9** [10], 15–17 (1933).—S. discusses tank blocks of a new design and size placed after hot repairs at the Ivetski glassworks. The advantages of the blocks are enumerated. Illustrated. M.V.K.

Saving fuel with glass tank of unusual design. W. A. Ingler. *Ceram. Ind.*, **22** [3], 154 (1934).—The Holophane Co., Inc., of Newark, Ohio, has a glass tank with a double bridge wall separating the working and melting chambers. The glass passes from the melting chamber through the throat under the first section of the bridge wall and then upward through a 6- x 14-in. vertical channel in the second section of the bridge wall, flowing into the working chamber from the top rather than being forced in at the bottom. The tank is of the recuperator type, holds 11 tons of glass, 6 in the melting chamber and 5 in the drawing chamber, and is operated at a fuel saving of 33% over the usual tank of the same operating capacity. Tank blocks have a longer life. Several other advantages are listed. E.J.V.

Flameless furnaces and their use in glassmelting. N. P. Krasnikov. *Keram. i Steklo*, **9** [10], 11–15 (1933).—After discussing principles of flameless firing and describing different types of burners, K. enumerates advantages in using flameless firing for Fourcault channel and annealing furnaces. M.V.K.

Notes on tank furnace wear. E. J. C. Bowmaker and J. D. Cauwood. *Jour. Soc. Glass Tech.*, **17** [68], 433–51 (1933).—This paper describes the erosion and corrosion which occurred in gas-fired, colorless, bottle-glass tanks under conditions stated, and indicates the increase in

furnace life made during the past ten years. Detailed results for the wear obtained with certain tank bottoms are given, and the distribution of the wear is discussed. The erosion and corrosion of tank sides and bridge walls are also described and notes are given regarding vertical joints, the position of horizontal joints, the influence of adjacent blocks on the wear of an individual block, the effect of peak-load melting, and other data. The evolution of a satisfactory submerged throat is described, and results obtained with two such throats are cited. A.J.M.

Results from reconstructing a tank furnace supplying Fourcault machines. S. BERMAN. *Glass*, **11** [2], 52–58 (1934).—A glass tank constructed according to the Gobbe system was redesigned. The new construction is illustrated. These changes in construction allowed the plant efficiency to be increased 35 to 40% without any considerable capital expenditure. The specific fuel consumption was considerably decreased. The net cost of glass was lowered and the quality of the glass was somewhat improved. A.J.M.

Roirant machine makes American bow. ANON. *Amer. Glass Rev.*, **53** [21], 9–10 (1934).—Illustrated. A.J.M.

Caspar Wistar started first successful glasshouse 194 years ago. ANON. *Amer. Glass Rev.*, **53** [20], 9–10 (1934).—A short description of Wistar's glassworks and pieces made there is given. A.J.M.

Small pots and hemlock fuel used in window glass factory 94 years ago. ANON. *Amer. Glass Rev.*, **53** [15], 19–20 (1934). A.J.M.

Old English glass. No. 49. FRANCIS BUCKLEY. *Glass*, **11** [2], 66–67 (1934).—This article deals with the work of amateur engravers. Illustrated. For No. 48 see *Ceram. Abs.*, **13** [4], 87 (1934). A.J.M.

Exhibition of a well-known collection of glass. K. HERAIN. *Sklářské Rozhledy*, p. 73 (1933).—The Museum of Art and Industry at Prague owns Europe's largest collection of glass tableware. R.B.

Glass faces exterior of radio station. ANON. *Ceram. Ind.*, **22** [3], 133 (1934).—Approximately 2200 sq. ft. of structural glass faces the exterior of radio station KMBC at Kansas City, Mo. Details of the use of black and white Carrara glass for the building exterior are given. Illustrated. E.J.V.

BOOKS

Synthetic and imitation gems. Monograph on gem stones. IMPERIAL INST. H. M. Stationery Office. 2s 6d, net. Reviewed in *Chem. Trade Jour.*, **93** [2425], 343 (1933).—Imitation of precious stones is achieved by (1) artificial production of the mineral, (2) substituting one stone for another, sometimes after altering the color, (3) simulating the stone in glass or other artificial product, or (4) employing composite stones. The only precious stones which can be manufactured with commercial success are the gem varieties of corundum and spinel. Pure alumina is mixed with a suitable amount of another metallic oxide. A stream of this mixture is allowed to fall into a jet of an oxy-coal-gas flame impinging on a rotating fireclay support. A pear-shaped mass of fused alumina slowly forms which when cooled is known as a "boule." Such material when cut and polished exhibits all the properties of a natural ruby or sapphire. A new artificial stone has recently been introduced in various colors; it is produced by a process similar to that outlined above but contains 10% MgO and closely resembles spinel. The glass used for gem stones is specially made to have a high refractive index and specific gravity and is known as "paste" or "strass." It is suitably colored by various metallic oxides and then cast in molds cut to the shape required. All glass substitutes are soft and easily scratched and all are isotropic. M.V.K.

Wealden glass: The Surrey-Sussex Glass Industry (A.D. 1226–1615). S. E. WINBOLT. ix + 85 pp. Combridges, Hove, 1933. Price 10s 6d. Reviewed in *Times Lit. Supp.*, **32**, 893 (1933); see also *Ceram. Abs.*, **12** [2], 57 (1933). H.H.S.

PATENTS

Laminated glass and method of making. W. H. MOSS (Celanese Corp. of America). U. S. 1,947,486, Feb. 20, 1934.

Method of making glass article. W. A. INGLER (Holophane Co., Inc.). U. S. 1,947,526, Feb. 20, 1934.

Process for producing colored coatings of glass. NORBERT KREIDL. U. S. 1,947,781, Feb. 20, 1934. The process produces red colored coatings, patterns, etc., on glasses, and comprises applying and then firing on sulfide glasses compositions containing those copper compounds which are reducible by sulfide glasses.

Glassworking method and machine. B. T. HEADLEY AND P. H. THOMPSON (Hartford-Empire Co.). U. S. 1,948,218 and 1,948,219, Feb. 20, 1934.

Apparatus for producing sheet glass. CARROLL CONE (Libbey-Owens-Ford Glass Co.). U. S. 1,948,563, Feb. 27, 1934.

Machine for sealing laminated glass. J. L. DRAKE (Libbey-Owens-Ford Glass Co.). U. S. 1,948,566, Feb. 27, 1934.

Apparatus for grooving laminated glass. W. G. HULLHORST (Libbey-Owens-Ford Glass Co.). U. S. 1,948,581, Feb. 27, 1934.

Lens. E. D. TILLYER (American Optical Co.). U. S. 1,948,636, Feb. 27, 1934. H. A. TOULMIN, JR. (Univis Corp.). U. S. 1,949,698, March 6, 1934.

Headlight reflector. C. E. ROSE. U. S. 1,948,680, Feb. 27, 1934.

Manufacture of glassware. ADOLF SCHILLER. U. S. 1,948,682, Feb. 27, 1934.

Glassblowing machine. J. W. LYNCH AND E. G. BRIDGES (Lynch Corp.). U. S. 1,948,928, Feb. 27, 1934.

Apparatus for drawing tubular bodies of glass. JEAN CARDOT (Corning Glass Works). U. S. 1,949,037, Feb. 27, 1934.

Glass furnace. L. D. SOUBIER (Owens-Illinois Glass Co.). U. S. 1,949,380, Feb. 27, 1934.

Bifocal lens. H. A. TOULMIN, JR. (Univis Corp.). U. S. 1,949,699, March 6, 1934.

Method of coloring vitreous articles. GAMES SLAYTER (Owens-Illinois Glass Co.). U. S. 1,949,884, March 6, 1934.

Glassware forming machine. L. D. SOUBIER AND J. E. COLLINS (Owens-Illinois Glass Co.). U. S. 1,949,886, March 6, 1934. J. P. BENOIT AND L. D. SOUBIER (Owens-Illinois Glass Co.). U. S. 1,949,894, March 6, 1934.

Method for making blown glass articles. L. D. Soubier (Owens-Illinois Glass Co.). U. S. 1,949,887, March 6, 1934.

Building block. S. S. Cochrane and August Kadow (Owens-Illinois Glass Co.). U. S. 1,949,898, March 6, 1934.

Method and apparatus for making glassware. J. E. Collins and J. E. McLaughlin (Owens-Illinois Glass Co.). U. S. 1,949,899, March 6, 1934.

Apparatus for fire finishing glass articles. R. A. Cosh (Owens-Illinois Glass Co.). U. S. 1,949,901, March 6, 1934.

Spun glass method and apparatus. H. J. Blum. U. S. 1,950,219, March 6, 1934.

Glass machine. K. W. Sommer and Paul Maca (Sommer and Maca Glass Machinery Corp.). U. S. 1,950,758, March 13, 1934.

Combined headlight lens and reflector. R. A. Forbes (Walter M. Kaefer). U. S. 1,950,918, March 13, 1934.

Method of manufacturing glass wool sheets for primary and secondary batteries, filtration, etc. British Glass Wool Co., Ltd., and A. R. Holmes. Brit. 406,085, Feb. 28, 1934.

Street-lighting glassware. Holophane, Ltd., and S. English. Brit. 406,141, Feb. 28, 1934.

Glass which resists attack by metal vapors. Jenaer Glaswerk Schott & Gen. Brit. 406,142, Feb. 28, 1934.

Process of manufacturing multicellular glass. Soc. anon. des manufactures des glaces et produits chimiques de St. Gobain, Chauny, et Cirey. Brit. 406,179, Feb. 28, 1934.

Production of sheets or articles of glass and analogous substances, and devices for using. S. W. Hamlyn and Dernier & Hamlyn, Ltd. Brit. 405,253, Feb. 14, 1934.

Melting or conditioning glasses, enamels, etc. British Hartford-Fairmont Syndicate, Ltd., and J. B. Murgatroyd. Brit. 405,361, Feb. 14, 1934.

Glassworking processes and furnaces. É. Péchoz. Brit. 405,806, Feb. 21, 1934.

Process and apparatus for applying edge-sealing material to laminated glass. A. H. Stevens (Duplate Corp.). Brit. 405,850, Feb. 21, 1934.

Molds for making glassware. H. Neuhauss. Brit. 405,889, Feb. 21, 1934.

Machine for making hollow glassware. United Glass Bottle Manufacturers, Ltd., T. C. Moorshead, and E. P. Dorman. Brit. 405,898, Feb. 21, 1934.

Manufacture of composite glass sheets. Soc. anon. des manufactures des glaces et produits chimiques de St. Gobain, Chauny, et Cirey. Brit. 405,918, Feb. 21, 1934.

Reception and transport table for laminated glass sheets. Herzogenrather Glaswerke Bicheroux & Cie. G.m.b.H. Fr. 41,519, Jan. 28, 1933. Addition to 600,182. (*C.A.*)

Ceramic materials. Soc. Quartz & Silice. Fr. 41,648, Feb. 15, 1933. Addition to 620,356. Electric insulators, etc., are made by mixing debris from fused SiO_2 with an appropriate binder. (*C.A.*)

Apparatus for drawing sheets of glass. N. V. Hollandsche Maatschappij voor de Vervaardiging van Glas. Fr. 749,107, July 18, 1933; see also *Ceram. Abs.*, **13** [3], 60 (1934). (*C.A.*)

Safety glass. Ignacio Sagnier Vidal. Fr. 749,134, July 18, 1933. The reinforcing layer between the glass sheets is composed of 2 thicknesses, one of which is a material capable of adhesion to the glass with facility, such as celluloid, and the other a material which resists the action of light and heat without liberating gases, such as cellulose acetate. (*C.A.*)

Transparent siliceous materials. Compagnie Française pour l'exploitation des procédés Thomson-Houston. Fr. 749,436, July 24, 1933. A material suitable for insulation in spark plugs, etc., is made by fusing together crystallized quartz and beryl ($Si_6O_{18}Al_2Be_3$). The best proportion is 3 to 5% of beryl. Al_2O_3 may be added if desired. (*C.A.*)

Cylinders for drawing sheets of glass. Pilkington Bros., Ltd. Fr. 749,572, July 26, 1933 (*C.A.*)

Apparatus for making glass articles such as bottles. Hartford-Empire Co. Fr. 750,558, Aug. 12, 1933. (*C.A.*)

Safety glass. Fritz Eckert. Fr. 750,650, Aug. 14, 1933. Safety glass is composed of sheets of tempered glass combined with one or more intermediate elastic sheets. (*C.A.*)

Laminated glass. Schlesische Spiegelglas-Manufactur Carl Tielsch G.m.b.H. Fr. 751,686, Sept. 7, 1933. The glass is made up of a number of thin sheets, one or more of which give special effects such as of color or design. (*C.A.*)

Apparatus for rolling reinforced glass. Pilkington Bros., Ltd. Fr. 752,185, Sept. 18, 1933. (*C.A.*)

Glass. Jakob Dichter. Fr. 753,257, Oct. 12, 1933. Means for transporting cut tubes to the blowing or forming molds. (*C.A.*)

Composite glass. Lonza (usines électriques et chimiques) (Soc. anon.). Fr. 753,271, Oct. 12, 1933. The plastic layer is made translucent or opaque by various additions or has designs worked therein to give marble, metal, and other effects. The sheets find various decorative uses. (*C.A.*)

Rolling wire glass. Chance Bros. & Co., Ltd. Ger. 572,591, March 2, 1933. (*J.S.G.T.*)

Construction of mesh for wired glass. A.-G. für Glasindustrie vorm. F. Siemens. Ger. 573,024, March 9, 1933. The warp wire in mesh formed of crossing wires is made to form a loop at each crossing through which the weft wire is threaded. (*J.S.G.T.*)

Production of wired glass. S. C. Schmidt Drahtwerke A.-G. Ger. 574,296, March 23, 1933. The joints of the wire mesh are flattened by a suitable device down to the thickness of a single wire before embedding in the molten glass. (*J.S.G.T.*)

Making narrow-mouthed vessels by the press and blow process. A. E. Smith. Ger. 574,974, March 30, 1933. The parison is pressed by a cooled plunger from the bottom. The supply of cooling medium regulates the extent of the chilling. See also *Ceram. Abs.*, **13** [4], 87 (1934). (*J.S.G.T.*)

Changing lettering on molds. Glashüttenwerke Phönix G.m.b.H. Ger. 575,618, April 13, 1933. In molds having figures, letters, or patterns carried on sepa-

rate portions adapted to be inserted through suitably disposed openings in the mold body, portions are carried on endless belts or on disks capable of rotation in such a way that they can be turned to the desired lettering and then registered in the opening. (*J.S.G.T.*)

Apparatus for drawing spiral glass rods. COSIFA G.M.B.H. PRODUKTION ELECTROTECHNISCHE ARTIKEL. Ger. 576,873, May 20, 1933. (*C.A.*)

Device for melting off rough ends of hollow glassware. LIBBEY GLASS MANUFACTURING CO. Ger. 577,890, June 7, 1933. (*C.A.*)

Apparatus for rolling wire-netting glass. SOC. ANON. DES MANUFACTURES DES GLACES ET PRODUITS CHIMIQUES DE SAINT GOBAIN, CHAUNY ET CIREY. Ger. 578,865, June 17, 1933. (*C.A.*)

Decolorizing glass. HANS LÖFFLER (Deutsche Gasglühlicht-Auer-G.m.b.H.). Ger. 578,866, June 20, 1933. Glass is decolorized by additions of oxides of Ce, Se, and other trivalent rare earths such as La, Nd, and Pr. (*C.A.*)

Glass. HANS G. GRIMM AND PAUL HUPPERT (I. G. Farbenind. A.-G.). Ger. 580,295, July 8, 1933. SiO_2 normally used in making glass is replaced wholly or in part by $AlPO_4$ in the proportion of 1 mol of $AlPO_4$ for each 2 mols of SiO_2. The $AlPO_4$ may be added as such or formed in the melt. Glass of high transparency to ultra-violet rays is obtained. Examples are given. See also Ger. 556,895, *Ceram. Abs.*, **12** [9], 328 (1933). (*C.A.*)

Glass transparent to ultra-violet rays. GEORG JAECKEL (Sendlinger optische Glaswerke G.m.b.H.). Ger. 583,001, Aug. 26, 1933. Glass of high transparency to ultra-violet rays contains BaO at least 10 and B_2O_3 not more than 10%, and not more than 3.5 mols of acid (SiO_2 + B_2O_3) per molecule of base (BaO + Na_2O and (or) K_2O, with or without ZnO). The glass contains no As_2O_3, practically no Fe_2O_3, and preferably no CaO. A specified composition is SiO_2 59, B_2O_3 4, Na_2O 7, K_2O 7, BaO 19, and ZnO 4%. (*C.A.*)

Continuous apparatus for drawing glass or wired glass strip. HUGO KNOBLAUCH. Ger. 584,015, Sept. 13, 1933, and 584,391, Sept. 19, 1933. (*C.A.*)

Apparatus for drawing glass tubes. SOC. ANON. "LE PYREX." Ger. 584,162, Sept. 15, 1933. (*C.A.*)

Press for making nonsplintering glass. CARL SCHAEFER. Ger. 584,171, Sept. 15, 1933. (*C.A.*)

Apparatus for making glass strip with a surface of colored glass. DEUTSCHE SPIEGELGLAS-A.-G. Ger. 584,214, Sept. 16, 1933. (*C.A.*)

Method of hardening sheet glass by blowing with air. SOC. ANON. DES MANUFACTURES DES GLACES ET PRODUITS CHIMIQUES DE ST. GOBAIN, CHAUNY, ET CIREY. Ger. 584,217, Sept. 16, 1933. (*C.A.*)

Apparatus for making glass filaments. BORNKESSEL BRENNER UND GLASMASCHINEN G.M.B.H. Ger. 584,215 and 584,216, Sept. 16, 1933. (*C.A.*)

Tank furnace for glass manufacture. DEUTSCHE LIBBEY-OWENS GES. FÜR MASCHINELLE GLASHERSTELLUNG A.-G. Ger. 584,388, Sept. 19, 1933. (*C.A.*)

Resistance furnace, with auxiliary gas burner, for glass manufacture. PATENT-TREUHAND-GES. FÜR ELEK. GLÜHLAMPEN M.B.H. Ger. 584,389, Sept. 19, 1933. (*C.A.*)

Hardening glass disks or plates by air-cooling. SOC. ANON. DES MANUFACTURES DES GLACES ET PRODUITS CHIMIQUES DE ST. GOBAIN, CHAUNY ET CIREY. Ger. 586,478, Oct. 21, 1933. (*C.A.*)

Tunnel furnace for melting glass and firing painted glassware. YA. I. GUROVICH. Russ. 30,403, July 31, 1933. (*C.A.*)

Structural Clay Products

Development of a lightweight ceramic body. C. M. NICHOLSON. *Jour. Can. Ceram. Soc.*, **2**, 60 (1933).—N. gives a large list of references, summarizes the literature, and cites English and U. S. patents with notes on each. His work consisted of a study of (1) the most desirable lengths of cut straw, (2) methods and conditions of cutting the straw to preserve its cylindrical form, (3) methods of forming the ware, (4) most suitable types of clay, and (5) modulus of rupture of the fired bodies. With straw cut 1 in. in length all trials cracked in drying. Straw cut 1/4 and 1/2 in. in length proved usable. To avoid flattening during cutting the straw was well soaked in water, cut, and dried; each short length then assumed its original cylindrical shape. Alluvial clay blended with 50% straw soft mud, was reduced 32% in weight and had a modulus of rupture of 815 lb. A plastic shale with 50% straw was reduced 33.7% in weight and had a modulus of rupture of 245 lb. A very sandy stoneware clay with 50% straw was reduced 39.1% in weight with a modulus of rupture of 166 lb. (underfired). The most favorable product for sound-proofing and acoustical purposes was produced by the casting process using a stoneware clay slip weighing 25 1/2 oz. per pint and lightly mixing it with an equal or somewhat greater volume of dry, short-length cut straw. J.G.P.

Sewer pipe and its problems. PAUL E. COX. *Brick Clay Rec.*, **84** [2], 58–59 (1934).—The failure of the sewer-pipe manufacturers to follow their product into the installation by working out a suitable jointing mixture has proved a serious detriment to sewer-pipe sales. New ideas should be tried as there has been practically no change in methods from the original production of pipe. Quality workmanship in installing sewer pipe is also necessary for it to hold its place against competitive products installed by high class workmen. For previous abstract see *Ceram. Abs.*, **13** [4], 89 (1934). E.J.V.

Accelerated and actual freezing and thawing tests of structural ceramic materials. W. E. PATTERSON. *Jour. Can. Ceram. Soc.*, **2**, 27 (1933).—The purpose of the proposed method is to judge the behavior of a structural unit in combination with mortar and (either free or loaded) under the precise condition and set up in the precise manner in which it is intended to be used. J.G.P.

Effect of weathering shale on the size and properties of

face brick. C. A. BOOTH. *Jour. Can. Ceram. Soc.*, **2**, 33 (1933).—Weathering on Lorraine shale does not penetrate a large pile any appreciable distance in a year. Material taken 2 ft. below the surface has no more shrinkage than newly quarried shale in either the dry-press or stiff-mud process. J.G.P.

Tentative standards for paving brick. O. KALLAUNER. *Stavivo*, p. 215 (1933).—No. 1 quality: apparent specific gravity of at least 2.1, absorption 2%, crushing strength 1600 kg./cm.², resistance to abrasion 0.25/cm.², impact strength for falling weight, 3 kg. through 130 cm., resistance to frost, allowance for length and width 2.5%, for thickness 5%. No. 2 quality: apparent specific gravity of at least 2.0, absorption 6%, crushing strength 1200 kg./cm.², resistance to abrasion 0.50/cm.², impact strength for falling weight, 3 kg. through 110 cm., resistance to frost, allowance for length and width 3.5%, for thickness 5%. R.B.

Color and brick. FR. KLEIN. *Ziegelwelt*, **64**, 172–73 (1933). (*C.A.*)

The brick of the future. KAREL JEŽEK. *Stavivo*, p. 122 (1933).—The engineers, K. and R. Ježek, at Blansko have constructed a revolving press for the production of hollow tile closed on five sides. The tile have been called "Jestav-brick." The weight of one tile is about 6 kg., 40% less than the weight of a full brick of the same size. Illustrated. R.B.

Hollow tile closed on five sides. KAREL PŘIKRYL. *Stavivo*, p. 166 (1933).—The fifth side of an auger-made hollow tile is closed on a press called "Jestav." R.B.

Paving brick. O. KALLAUNER. *Stavivo*, p. 135 (1933).—In Moravia, Mikulov has a brick pavement used since 1907 and Hrušovany has one used since 1908. The brick are from the Šatov works near Tnojmo where paving brick have been manufactured since 1890. A description of stiff-mud and dry-press manufacture by Monier in France since 1928 is given. R.B.

PATENTS

Gray fired brick and method of making. R. L. ATKINSON (Arthur D. Little, Inc.). U. S. 1,949,524, March 6, 1934.

Production of brick and tile. VÁCLAV RYCHLÍK. Czechoslo. P–4351, May 30, 1930; *Cement a beton*, p. 22 (1933).—The raw material is mixed with carbonaceous matter of low combustibility or matter partly burned. Coal fines in amounts to 20% may be added. R.B.

Structural tile. A. TUPLER. Czechoslo. P–2416–30; *Stavivo*, p. 205 (1933).—Cylindrical pieces attached to the side faces of the tile have openings which allow the units to be joined with iron rods. R.B.

Permeable brick. VÁCLAV RYCHLÍK. Czechoslo. P–4351–31; *Stavivo*, p. 206 (1933). R.B.

Porous brick and pottery. AAGE NIELSEN. Ger. 583,301, Sept. 1, 1933; see Fr. 735,954, *Ceram. Abs.*, **12** [6], 226 (1933). (*C.A.*)

Apparatus for making cellular products from fused materials. WILHELM BENZINGER. Ger. 583,470, Sept. 4, 1933. (*C.A.*)

Refractories

Identification of crystalline substances by means of X-rays. B. E. WARREN. *Jour. Amer. Ceram. Soc.*, **17** [4], 73–77 (1934).

Olivine as a refractory. R. A. HEINDL AND W. L. PENDERGAST. *Bur. Stand. Jour. Research*, **12** [2], 215–22 (1934); R. P. 645.—Olivines representing three different deposits in N. C. and one each in Calif., British Columbia, and Russia were tested to determine the possibilities of the material as a refractory. The following results were reported: (1) The chemical analyses showed the silica to range from 40 to 45%, magnesium oxide 40 to 49%, iron as ferrous oxide 7 to 15%, and lesser amounts of alumina, calcium oxide, and titanium. (2) The rate of thermal expansion was fairly regular from room temperature to 900°C except for slight irregularities between 200 and 300°C, and between 650 and 700°C. The total expansion at 900°C ranged from 0.942 to 1.082%. (3) The true specific gravity ranged between 3.206 and 3.420 for the raw material and between 3.294 and 3.434 for the material after heating to 1400°C. (5) The softening point of the raw ore ranged from cone 30 to above cone 35 except for the material high in calcium oxide which varied from cones 11 to 16. (6) The olivines from N. C. were more refractory than those from the other sources. (7) The petrographic examination indicated the material to be essentially olivine although the percentages of forsterite and fayalite varied quite appreciably with the respective olivines. R.A.H.

Behavior of alumina and silica with metal sulfides in relation to alumina recovery from siliceous raw material. X. SIEBERS AND E. J. KOHLMEYER. *Arch. Erzbergbau Erzaufbereit. Metallhüttenw.*, **1**, 97–129 (1931).—In the Haglund process for the recovery of Al_2O_3 from bauxite, bauxite is melted in an electric furnace with FeS and C. Silica separates as an Fe-Si alloy, while Al_2S_3 lowers the melting point of the Al_2O_3, improving it for electrolysis. Al_2S_3-Al_2O_3 mixtures give the lowest melting point (1008°) with a 1:1 mixture. Al_2O_3 begins to react with FeS or ZnS and C at 1300°. At 1500° reaction proceeds with considerable velocity. Because of the solution of reaction products in the melt, only part of the Al_2O_3 is converted to Al_2S_3. Metallic Si does not react with Al_2S_3 at 1000 to 1500°, but SiO_2 reacts with Al_2S_3 in a graphite crucible at 1150°, almost completely to form SiS at 1450°. In N_2 at atmospheric pressure ZnS begins to volatilize at 1150° and sublimes at 1470°. ZnS plus C begins to volatilize at 1000° and sublimes at 1350°. ZnS plus Si begins to volatilize at 900° and sublimes at 1150°. ZnCS is first formed, which reacts with SiO_2 in the presence of more C. SiO_2 can be volatilized from kaolin, alumina, and bauxite mixtures with ZnS and C as easily as with SiO_2 alone, but when FeS and C are used, reaction products are partly soluble in the melt, and complete volatilization of the SiO_2 does not occur. TiO_2 reacts with ZnS and C to form a sulfide, which is not easily volatilized. Up to 1600° the TiO_2 in bauxite is not reduced, so that the Fe-Si alloy is free from Ti. (*C.A.*)

Production of alumina from aluminum silicates. Yo-

GORO KATO. *Jour. Electrochem. Assn.* [Japan], **1**, 154–59 (1933).—Upon standing for 2 or 3 hr. a mixture of Al silicates and concentrated H_2SO_4 at 200° showed 95% conversion into $Al_2(SO_4)_3$. No stirring under high pressure is required but slight heating is necessary in some cases. Upon extraction pure crystalline $Al_2(SO_4)_3 \cdot 18H_2O$ free from Fe and Ti was obtained with but 0.1% of FeO based upon Al_2O_3 even from the aqueous solution containing 10% of ferric salt. Action of NH_3 gas on $Al_2(SO_4)_4 \cdot 18H_2O$ in aqueous solution gives easily washable crystalline $Al(OH)_3$. Ferric salt is precipitated before the $Al(OH)_3$; upon igniting the $Al(OH)_3$ very pure alumina is obtained. (*C.A.*)

"Reversible" thermal expansion of a silica brick. J. A. SUGDEN. *Jour. Soc. Glass Tech.*, **17** [68], 378–82 (1933).—The thermal expansion of a silica brick over the temperature cycle 20 to 700 to 20° was found to be not strictly reversible; a small permanent expansion was observed. The extent of the permanent expansion rapidly decreased with each repetition of the cycle, and a decreased expansion over the range 20 to 700° occurred during each successive heating. A simple quantitative relationship was found between the decrement in expansion up to 700° and the corresponding permanent expansion. The mechanism of the expansion of an agglomerate is discussed in connection with the above relationship. A.J.M.

Improving the quality of silica brick. ANON. *Tonind.-Ztg.*, **58** [3], 30–31 (1934).—A discussion is given of the volume stability of silica brick and means of achieving it according to German patents, including (1) the use of calcium compounds, boric, phosphoric, and tungstic acids as mineralizers, (2) combining quartzite with bonding clay electrolytically liquefied, (3) additions of alkalis and of nonalkaline oxides to the silica mix containing lime, (4) additions of metallic materials such as copper, tin, antimony, lead, chromium, manganese, nickel, cobalt, etc., or their alloys or silicides, (5) additions of zirconium oxide or silicon carbide. M.V.K.

Dilation and sensitivity of refractory brick to heat. ANON. *Rev. mat. constr. trav. pub.*, No. 290, pp. 213–14*B* (1933). M.V.K.

Electrocast. VLADIMÍR ŠKOLA. *Stavivo*, p. 33 (1933).—One of the oldest patents applying to the production of ceramic ware by melting the raw materials is the German patent No. 104,298 granted in 1898. Corning Glass Works, about ten years ago, put the first practical solution of this problem on the market, the Corhart Electrocast. Later production was begun at Modane, France, and at Falknov, Bohemia. While in America diaspore and kaolin are the raw materials, in Europe bauxite, refractory clays, and kaolin are used. Revolving resistance furnaces with a power consumption of about 500 kw. at temperatures of 1870 to 2200°C are used. They give an hourly output of about 300 kg. of molten material. Ferrosilicide is gained as a by-product. The cast blocks have some characteristics of both refractories and glass. The German Patent Office classifies such products as ceramic ware. See also *Ceram. Abs.*, **13** [3], 64; [4], 93 (1934). R.B.

Refractories and super-refractories. D. PETIT AND MAIRE. *Congrès du Chauffage Industriel Preprints*, Group 4, Section 1, 6 and 4 pp. (1933); *B.B.N.F.M.R.A.*, Serial 12, pp. 964–65.—P. deals with recent progress in production of industrial refractories and M. discusses carbon silicide and fused alumina and their applications. (*B.B.N.F.M.R.A.*)

Artificial corundum. Production methods and properties. JOHN G. STEIN & Co. *Refrac. Bull.*, No. 23 (Nov., 1933); abstracted in *Chem. Trade Jour.* [London], **93** [2431], 451 (1933).—Four definite crystalline modifications of alumina are known: (1) Alpha-alumina, or artificial corundum, is formed by heating the hydrates or other salts such as the chloride, nitrate, or sulfate to a sufficiently high temperature. It is also formed where fused alumina solidifies. (2) Beta-alumina is produced by fusing alumina with small amounts of magnesia or sodium carbonate. (3) Gamma-alumina is formed by heating the hydrates between 500 and 1100°; it also appears in clays when they are heated between 900 and 1100°. (4) Zeta-alumina has been noted only in special melts containing lithium oxide. Alpha-alumina (artificial corundum) can be produced by the following methods: (*a*) fusion process (Haglund), in which impure alumina hydrate (bauxite) is mixed with carbon and iron sulfide and heated; the molten mass forms two layers, an alumina-aluminium sulfide slag containing 80% alumina, and a lower layer consisting of an iron-silicon alloy; (*b*) alkali process (Bayer), in which the alumina is extracted by alkali from bauxite, alumina hydrate being precipitated from the resulting sodium aluminate solution; and (*c*) acid process, in which alumina is dissolved from clay by a mineral acid, the aluminium salt being subsequently decomposed by heat. Corundum (α-alumina) is extremely hard and highly refractory (melting point 2050°) and it retains its rigidity and load-bearing capacity up to over 1750°. It has a straight-line expansion curve, which enables it to resist thermal shock, and it resists the action of reducing gases such as H_2 and CO and tends to be more acidic than basic at high temperatures. With bases it generally forms high-temperature compounds of the spinel type. From the melting curves (Wartenberg and Reusch, *Ceram. Abs.*, **12** [2], 63 (1933)), the effectiveness of compounds in lowering the melting point of corundum is, in increasing order, MgO (ZnO, NiO), TiO_2, SiO_2, CoO, Cu_2O, CaO, Fe_2O_4, and Mn_3O_4. The production of corundum refractories and their application in industry are briefly discussed. M.V.K.

Mullicor, a new ceramic material. B. A. KHIZH AND S. I. SKOBLINA. *Keram. i Steklo*, **9** [9], 24–26 (1933).—A series of experiments, based on the assumption that the dimensions of the grain of aluminium oxide and its shape have a great effect on the temperature of vitrification of the body, were made on mixes consisting of (1) Al_2O_3 as oxide (obtained from bauxite) with kaolin in varying proportions and (2) Al_2O_3 (natural corundum) and kaolin. The results are tabulated and shown on curves. It was found that in mixes of (2) the porosity of the body increases with the corundum content, while in mixes of (1) the body becomes more dense with the increasing Al_2O_3 content (up to 80% Al_2O_3 and 20% kaolin); after this the body becomes porous again. Bodies produced from Mullicor mixes have a vitrified body and are only slightly inferior to the German sintered corundum bodies. M.V.K.

Determination of exact specific gravity of Dinas. P. P. Budnikoff, A. A. Grebenik, and V. I. Endovitzkiĭ. *Zavodskaya Lab.*, No. 5, pp. 27–29 (1933).—Samples varied from 2.32 to 2.51. (*C.A.*)

Effect of MgO on physicochemical properties of Dinas brick. P. P. Budnikoff and N. S. Kassiyan. *Domez*, No. 7, pp. 14–17 (1933).—Experimental brick containing 0, 0.2, 0.3, 0.5, 1.0, and 2.0% MgO were prepared from mixtures of two kinds of quartzites. Microanalysis and macroanalysis and physicochemical tests showed that in every case the brick were of good quality. (*C.A.*)

Studies of refractory materials. XVI. Chromite. Anon. *Refrac. Jour.*, **10** [2], 70 (1934).—The composition and properties of chromite are described. For Part XV see *Ceram. Abs.*, **13** [4], 100 (1934). A.J.M.

Grain structure and physical properties of granulated special refractory materials. H. Adler. Doctor's Dissertation, Darmstadt, 1933. Reviewed in *Feuerfest*, 9 [12], 163 (1933).—Equations for porosity and inner surfaces of different granulations are developed and from them requirements for the optimum properties are deduced. The results are applied for the manufacture of silica brick from quartz sand. Improvements in the analysis by sedimentation are discussed which show an independence of temperature and enlarge the range of measurements. M.V.K.

The term "refractoriness." Wa. O. *Feuerungstechnik*, **22** [1], 12 (1934).—A discussion of the term "refractoriness", which in some cases is technologically irrational and lacks clearness, is given. M.V.K.

New ceramics of pure, highly refractory oxides. E. Rishkevich. *Elektrowärme*, **4** [2], 30–31 (1934).—The particular difficulties in using metal oxides with very high melting points as refractory materials due to their low plasticity and deformability are discussed. Al_2O_3 in the system Al_2O_3–SiO_2 is used chiefly; its melting point is 2050°C and it is at present possible to make an absolutely dense and chemically permanent product even at 1800°C. Pyrometer tubes are made of it. BeO is superior; its melting temperature is 2500° and its chemical stability is great especially against reducing influences; its electrical resistance is higher than that of Al_2O_3. It must be protected at high temperatures from contact with other oxides, however, as easily melting compounds might be formed. ZrO_2 is not attacked by strongly acid and strongly basic substances, C, H, and sulfuric vapors. Objects made of ZrO_2 can be used up to 2500°C. It is not quite as dense as Al_2O_3 or BeO; the electrical conductivity is considerably higher as in other pure, refractory oxides. At high temperatures, ZrO_2 with C forms a carbide at the surface which oxidizes again to ZrO_2. Magnesia has 96 to 97 MgO content. Magnesite brick can be used up to 2400°; at 2000° under a pressure of 2 kg./cm.² they show no softening if made from pure material. MgO apparatus is particularly suitable for use with basic slags, in melting Pb, etc. ThO_2 has the highest melting point, 3000°C, a specific gravity of about 10, and is resistant to basic substances. High thermal expansion coefficient and low temperature conductivity are a drawback. Zirconium silicate ($ZrSiO_4$) and spinel ($MgOAl_2O_3$) are used for apparatus, crucibles, tubes, etc., for temperatures up to 1750 and 2000°C, respectively. M.H.

Recording kiln-brick performance. T. N. Haffner. *Pit & Quarry*, **26** [9], 46 (1934).—A graphic method of showing the length of service of kiln brick was designed. Illustrated. E.J.V.

Application of insulating materials to industrial furnaces. J. D. Keller. *Jour. Amer. Ceram. Soc.*, **17** [4], 77–87 (1934).

Ceramic insulating parts for electric resistance heating. E. Albers. *Elektrowärme*, **4** [2], 25–29 (1934).—Ceramic bodies used in resistance furnaces are discussed as to stability against temperature fluctuations, mechanical strength, insulating capacity at elevated temperatures, and refractoriness. Means for improving these properties and formulas for their determination are developed from practice. Bibliography.

	Corundum with fire clay	Coarse-grained fire clay with soapstone	Fine-grained fire clay without soapstone	Kaolin fire clay
Impact bending strength (kg. cm./cm.²)	1.6	1.5	1.75	1.7
Bending strength (kg./cm.²)	330	150–180	300–400	360
Tensile strength (kg./cm.²)	110	90	150	120
Compressive strength (kg./cm.²)	650	520	2000	1000
Expansion coefficient between 20 and 650°C	4×10^{-6}	4×10^{-6}	2.2×10^{-6}	4×10^{-6}
Specific insulating resistance (ohm/cm.) 300°	4×10^{7}	2.5×10^{8}	4×10^{8}	4×10^{8}
Specific insulating resistance (ohm/cm.) 500°	6×10^{5}	3×10^{6}	3×10^{6}	4×10^{6}
Specific insulating resistance (ohm/cm.) 700°	5×10^{4}	1.5×10^{5}	3.5×10^{5}	3.5×10^{5}
Softening temperature (°C)	1650	1430	1430	1700
Porosity (volume % approximately)	20	30	23	17
Density (g./cm.³)	2.3	1.95	1.8	1.9

M.H.

Economy of material for heat insulation. W. Fischer. *Elektrowärme*, **3** [8], 262–67 (1933).—Principles of comparing heat insulation with respect to efficiency and economy are discussed, formulas are developed, and tables are given for heat conductivity, expansion coefficients, (German) prices, weights, maximum temperatures for safe use, and mechanical strength. Directions are given for selection and design of the most economical wall thickness under given conditions. M.H.

Effect of thermal insulation on the structure of Dinas brick. P. I. Yudinson. *Keram. i Steklo*, **9** [9], 21–24 (1933).—Two Dinas brick used 10 months in the crowns of glassmelting furnaces were studied. One of them was from a crown with thermal insulation, while the other was not. The brick from the insulated crown still had a high mechanical resistance and was of a lighter color, while the other consisted of several easily crumbled pieces. Chemical analysis of both brick showed very little difference. The differences in the physical stability are due to structural changes occurring in the brick and not to chemical factors. Illustrated. M.V.K.

Thermal insulation of crowns of glass furnaces as a means of saving fuel and Dinas brick. N. P. Krasnikov. *Keram. i Steklo*, **9** [9], 20–21 (1933).—On the basis of theoretical considerations and experimental data, K. points out that thermal insulation of the crowns of glass furnaces permits the reduction of gas consumption by 10% and the total quantity of Dinas brick by half because

of a double increase in their life. Changes appearing in Dinas brick (connected with the formation of tridymite) occur irregularly and the brick become inhomogeneous when the crowns are not insulated; with a thermal insulation the tridymitization of the brick proceeds uniformly and the brick becomes more stable and durable.

M.V.K.

Control of the thermal properties of refractory materials. ROBERT HADFIELD AND R. J. SARJANT. *Refrac. Jour.*, **10** [2], 62–66 (1934).—Approximately one-third of the heat put into a furnace is lost through storage in the walls. Tables showing the distribution of heat losses in typical furnaces, the time to heat up, and the storage of heat in furnace walls are given. A.J.M.

Refractory concrete for boiler settings. ANON. *Eng. Boiler House Rev.*, **46** [5], 331 (1932); abstracted in *Feuerfest*, **8** [12], 179 (1932).—Durax I is a bauxitic refractory suitable for rapid repairs. Its refractoriness corresponds to Seger cone 37 (1830°) and it has a very small change in volume after drying and firing. Durax II is a dry powder used as ordinary concrete. The mass sets in 24 hr. without shrinking and its refractoriness corresponds to Seger cone 26 (1600°). Pyrocrete is a refractory material consisting of chromium oxide; it is utilized for the manufacture of stamped hearths of forge and firing furnaces; it is not affected by slag containing iron.

M.V.K.

Mined soapstone brick for boiler combustion chambers. O. V. NEFED'EVA, P. T. MAKUSHEVICH, AND A. I. DVORETZKII. *Izvestiya Teplotekh. Inst.*, No. 4, pp. 36–47 (1933).—The soapstone had the composition: SiO_2 32.50, Al_2O_3 2.60, Fe_2O_3 4.60, FeO 1.93, MgO 35.04, CaO 0.40, Na_2O + K_2O 0.75%, loss on ignition 23.37%, H_2O (at 105°) 0.04%. Specific gravity of the raw stone was 2.926 and of the fired stone (1300°) 3.265. The decomposition of $MgCO_3$ to MgO and CO_2 takes place at 800 to 900° and this heating period should be prolonged to avoid cracks due to the separation of CO_2. At 100° the talc is transformed into $MgO \cdot SiO_2$ and the zone of $2MgO \cdot SiO_2$ is reached at 1450°. Soapstone brick withstand 1300° without deterioration. They are resistant to basic slag. (*C.A.*)

Selection of lining for revolving furnaces when manufacturing Portland cement and sulfuric acid from gypsum and clay. P. P. BUDNIKOFF AND S. A. GICHAREVITSCH. *Tonind.-Ztg.*, **58** [7], 71–72; [8], 83–84 (1934).—For the zone of maximum dissociation of $CaSO_4$ and that of the sintering of the clinker, grog brick with a minimum alumina content of 42% should be used. The porosity of these brick should be 8% and the additional linear shrinkage should not exceed 0.5% with repeated firing for 2 hr. at 1450°. Periclase crystals of magnesite brick withstand the attack of clinker well, but the bonding materials do not. A considerable disadvantage of magnesite brick is their sensitivity to sudden temperature changes; they are easily destroyed by the reducing atmosphere at 1450°. Dinas brick having a specific gravity of 2.38 are strongly attacked, those having a specific gravity of 2.42 are corroded, and those having a specific gravity of 2.49, more. Black Dinas has a markedly greater strength. Semiacid brick (quartz-grog) are noticeably corroded. Chromite-magnesite brick withstood the tests well. The clinker does not enter into reaction with the brick. Their disadvantage is a high expansion due to heat. M.V.K.

Develop tests for bung brick. ANON. *Foundry*, **62** [1], 14 (1934).—The bung is submitted to actual service conditions and a direct comparison of the two types of brick is made. Illustrated. F.G.H.

Expansion of silica brick of the coke-oven lining during firing. M. I. TAGUNOV. *Coke and Chem.* [U. S. S. R.], No. 2, pp. 55–61 (1932).—A study of heat resistance and expansion of fire brick (approximate composition: SiO_2 95.5%, CaO 2.3%, Al_2O_3 1.1%, Fe_2O_3 0.6%; fusion 1710°; specific gravity 2.36) was made from plant observations. Data are tabulated. The following procedure is recommended for breaking in a newly lined coke oven: (1) drying for 20 days, average temperature rise 4 to 5° per day; (2) during the following 23 days, the temperature is raised from 105 to 420°; (3) during the next 15 days the temperature is raised to 900°; (4) finally for 8 days it is raised from 900 to 980°. (*C.A.*)

Sand-clay refractories and their use in glass furnaces. N. E ROMANCHA. *Keram. i Steklo*, **9** [9], 10–19 (1933).—Examples of the rational use of sand-clay refractories in various glassworks are described. The material is produced from a mixture of raw refractory clay (35%) and quartz sand (65%). Its melting temperature is from 1720 to 1750° and its behavior during melting is similar to that of silica brick. It an advantageously replace the latter in the crowns o small and medium-sized glass furnaces. The life of the setting of a tank made of sand-clay refractories is not shorter than that of average fire brick. Its defect is a low mechanical resistance. Its low price and the facility of its mechanical production make this material advantageous in many cases. M.V.K.

Slag-resisting crucibles for the coreless induction furnace. ANON. *Metallurgia*, **9** [50], 54 (1933).—Durable rammed-up crucibles are obtained when the refractory material is used in different gradings, part being in powder form. The finely ground material is mixed with a suitable bond which gives the necessary dry strength and facilitates sintering. Methods to reduce the effect of slag on crucibles and experiments with Siemensite (spinels of the composition FeO (Al_2O_3, Cr_2O_3) and MgO (Al_2O_3, Cr_2O_3) and a silica bond) as refractory material are mentioned. M.V.K.

Graphical methods for the calculation of furnace walls. W. FISCHER. *Elektrowärme*, **4** [2], 32–38 (1934).—Formulas for calculating furnaces with plane walls and tubular furnaces of large sizes for which the heat losses should not exceed a given maximum are developed with and without taking into account the temperature coefficient of the material. M.H.

Practical use of conductivity measurements in industry. HELLMUT REICHELT. *Chem. Fabrik*, pp. 341–42 (1933).—Six diagrams for wiring home-made apparatus are shown. (*C.A.*)

Progress in dolomite linings for furnaces. ANON. *Brit. Clayworker*, **42** [502], 319–21 (1934).—A historical review of dolomite refractories and various methods of calcining dolomite, its use in lining or relining different types of furnaces, and methods of ramming are discussed. R.A.H.

New checker brick gives more efficiency to stoves in

blast furnaces. WILLIAM M. BAILEY. *Brick Clay Rec.*, **84** [2], 56–57 (1934).—American open-joint checker brick are produced in four designs, intended to give a greater heating capacity at a lower cost than regular fire brick. A solid wall is insured and dead flues are eliminated as the horizontal interlocking prevents shifting and vertical side openings produce free cross-circulation with no horizontal surfaces so that no flue can clog for more than the length of one brick. The first installation used 1,300,000 lb. of these checker brick. Illustrated. E.J.V.

Fired clay used in steel industries. ANON. *Foundry*, **62** [1], 24 (1934).—The physical and chemical properties of calcined chamotte, a highly aluminous clay, for facing use in European steel foundries are described. F.G.H.

Furnace construction to reduce slag attack on refractories. F. H. NORTON. *Fuels & Fur.*, **12** [1], 11–17 (1934).—The value of various types of refractory for slag resistance is discussed. Several types of construction that will aid in increasing the slag resistance of the refractories are described. Illustrated. See also *Ceram. Abs.*, **12** [10–11], 378 (1933). E.J.V.

Shaping refractory brick. HANS KREMSKI. *Tonind.-Ztg.*, **58** [1], 4–5 (1934).—A description of the mechanical molding of grog brick, plugs, and molds for foundries is given. M.V.K.

Grinding and refractories research. ANON. *Chem. Trade Jour.* [London], **93** [2430], 431 (1933).—Reports made by Carey and Bosanquet (this issue, p. 127), Sugden (p. 120), and Inglis (p. 126) are discussed. M.V.K.

Luckenauer sagger clay of the Werschen-Weissenfelser Braunkohlen A.-G. OTTO KRAUSE. *Sprechsaal*, **67** [4], 43–45 (1934).—A description is given of the deposits, geological formation, structure, and chemical and ceramic properties of Luckenauer clay. Its high plasticity and capability of bonding make this clay especially suitable in the manufacture of saggers. M.V.K.

Evaluation of bauxites. I. N. MASLENITZKIĬ. *Gorno-Obogatitelnoe Delo*, No. 2–3, pp. 14–24 (1933).—M. discusses methods for the evaluation of Russian bauxites for metallurgical purposes. See also *Ceram. Abs.*, **11** [6], 370 (1932). (*C.A.*)

Kaolin, clays, and refractory materials in Italy. PASQUALE MORICA. *Corriere ceram.*, **14**, 79–96 (1933). (*C.A.*)

Deposits of refractory raw materials in Czechoslovakia. JAN STEJSKAL. *Zprávy Československ. keram. společnosti*, pp. 5–48 (1932).—Czechoslovakia is rich in first-quality kaolins, refractory clays, magnesites, graphites, and quartzites. The best kaolin is from the tertiary formation. The decay of mica minerals caused by organic acids and carbon dioxide produced this clay. The best Czechoslovakian kaolins originated in the environs of Karlovy Vary from granites, those near Plzeň from acroses, those near Kadaň and at Znojmo (Moravia) from gneiss. Refractory clays are found mainly in northwestern Bohemia and western Moravia. They belong to the following formations: permo-carbonic, jurassic, chalk, and tertiary. The best magnesite deposits are in Slovakia. They are equal to and, in many ways, surpass Styrian magnesite. In the Slovakian ore mountains a zone of magnesite deposits reaches 120 km. Bohemian graphite from Č. Krumlov is known even in foreign countries. For the manufacture of silica quartzites are used. The best of them are from oligocene and miocene formations in northern Bohemia. R.B.

BOOKS

Thermal Insulation. EZER GRIFFITHS. A reprint of 3 Howard Lectures, 48 pp. Royal Society of Arts, London, 1933. Price 2s 6d. Reviewed in *Trans. Inst. Chem. Eng.*, **10**, 35 (1932).—The second reprint deals with insulation at high temperature and describes the qualities of asbestos, alone or mixed with magnesia, plaster, clay, etc., of diatomaceous earth and brick, and of Fibrox (silicon oxycarbide). H.H.S.

Manufacture of Refractories for Glass Furnaces. K. F. LEONOV. State Chem. Trust, Moscow and Leningrad, 1932. 64 pp. Price 45 kopeks. Reviewed in *Keram. i Steklo*, **9** [9], 37 (1933).—This book describes in a popular way with practical data the requirements of refractories used in the glass industry and the manufacture of grog brick. M.V.K.

PATENTS

Method of manufacturing alumina. W. M. SANDERS (Kalunite Co.). U. S. 1,948,887 and 1,948,888, Feb. 27, 1934.

Refractory article. T. M. CAVEN (Corning Glass Works). U. S. 1,949,038, Feb. 27, 1934. A refractory article consists of refractory aluminum-oxide grains and a binding medium consisting of a refractory aluminum phosphate.

Treatment of aluminum hydrate. W. H. GITZEN (Aluminum Co. of America). U. S. 1,950,883, March 13, 1934. A method of producing alumina substantially free from soda from aluminum hydrate containing a small amount of soda as an impurity comprises calcining the hydrate at a temperature between 400 and 925°C and subsequently leaching the calcined product with a solution of an acid.

Checkerwork. E. A. BROWN, JR., AND M. M. MARKS. U. S. 1,951,047, March 13, 1934.

Method of construction of the masonry of industrial furnaces, particularly Siemens-Martin furnaces. C. OTTO & CO., GES. Brit. 405,527, Feb. 14, 1934.

Slip casting and molding of refractory oxides. F. L. CLARK AND IMPERIAL CHEMICAL INDUSTRIES, LTD. Brit. 405,978, Feb. 28, 1934.

Lining for electric furnaces. JOSEF EFFENBERGER. Czechoslo. P–5172, July 3, 1931; *Cement a beton*, p. 22 (1933).—Diatomaceous earth, to which 10 to 60% of refractory clay or kaolin has been added, is pugged, molded, dried, and fired to 400 to 1000°C. The calcined body is ground and, after a further addition of 10 to 60% of refractory clay, is molded, dried, and fired again to 500 to 1000°C. R.B.

Brick. HERMANN SALMANG AND BENNO WENTZ. Fr. 714,804, April 4, 1931. Brick of high resistance and maximum content of tridymite are made by adding an alkali and a flux for the alkali, such as an oxide of Mg, Fe, Zn, Ni, Co, or Mn, to the usual siliceous materials. Fr. 42,072, May 19, 1933. In making silica brick the desired degree of conversion to tridymite is obtained by regulating the amount of flux added and the temperature. The flux is added in an insoluble form. (*C.A.*)

Refractory carbides. N. V. PHILIPS' GLOEILAMPEN FABRIEKEN. Fr. 749,349, July 22, 1933. Refractory carbides are prepared by heating a body consisting, at least in part, of C to a suitable temperature in an atmosphere consisting of one or more volatile compounds of the elements of which it is desired to prepare the carbides, preferably in the presence of H. See also *Ceram. Abs.*, **12** [10–11], 381 (1933). (*C.A.*)

Fireproof building material. ARTHUR SPRENGER. Ger. 577,932, June 7, 1933. Oxides of Cr, Al, Mg, and Si are fused together at high temperatures the amounts being arranged so that the compounds $MgO \cdot Al_2O_3$, $MgO \cdot Cr_2O_3$, and $Al_2O_3 \cdot SiO_2$ result. Minerals or compounds containing oxides of the above may be used as starting materials. (*C.A.*)

Refractory masses. ARTHUR SPRENGER. Ger. 582,235, Aug. 11, 1933. Addn. to 577,932 (see preceding patent). (*C.A.*)

Silica brick. HERMANN SALMANG AND BENNO WENTZ. Ger. 570,215, Feb. 13, 1933. In making silica brick by the method of 555,767 (*Ceram. Abs.*, **12** [3], 114 (1933)), *i.e.*, by adding alkali compounds free from Al to a SiO_2 mass, the alkali is added as Na_2SiF_6. See also Ger. 557,286, *ibid.*, **12** [7], 268 (1933). (*C.A.*)

Heat-insulating composition. PAUL KAUFFMANN G.M.B.H. Ger. 582,368, Aug. 14, 1933. Siliceous residues from the manufacture of Al_2O_3 are mixed with lime and a solution of saponin or other foaming agent to produce a cellular mass, which is allowed to set in molds. (*C.A.*)

Silica brick. HEINRICH KOPPERS A.-G. Ger. 582,446, Aug. 15, 1933. Comminuted siliceous material such as quartzite or quartz sand is mixed at a raised temperature with quicklime and water, and the product is mixed with a further amount of siliceous material. The whole mixture is molded and fired. (*C.A.*)

Refractory masses. TURE R. HAGLUND. Ger. 582,800, Aug. 23, 1933. Highly fireproof masses are produced by fusing materials containing 80% or more of oxides of Mg, Al, and Cr, the residue being oxides of Si and Fe, with optional small amounts of CaO. See also Swed. 70,995, *Ceram. Abs.*, **12** [10–11], 381 (1933). (*C.A.*)

Cast refractory brick for Siemens-Martin furnaces, etc. ARTHUR SPRENGER. Ger. 583,125, Aug. 29, 1933. Constructional features are described. (*C.A.*)

Refractory compositions. VICTOR M. GOLDSCHMIDT (Rudolf Knudsen, co-inventor). Ger. 583,194, Aug. 31, 1933. Compositions consisting mainly of Mg orthosilicate are prepared by heating talc with MgO or magnesite to a temperature insufficient to fuse the mixture, *e.g.*, to 1300 to 1450°. Natural Mg orthosilicate may be added to the initial mixture. (*C.A.*)

Refractory ceramic articles. DEUTSCHE TON- & STEINZEUG-WERKE A.-G. Ger. 583,195, Aug. 31, 1933. Articles made from an ordinary ceramic composition are provided with an internal supporting framework of a material more highly resistant to temperature and pressure and of similar composition. Thus, a standard composition comprising chamotte and clay may be molded around a framework of SiC and then fired in the usual way. The products retain their shape when subjected to a bending force at a high temperature and pressure. (*C.A.*)

Porous refractory articles. N. V. VEREENIGDE NEDERLANDSCHE CHAMOTTE-FABRIEKEN. Ger. 586,442, Oct. 21, 1933. A mixture containing chamotte, refractory clay, and 50 to 90% by volume of Scottish cannel coal is molded and fired. The coal employed should yield not more than 10% of ash, which should be of high melting point. (*C.A.*)

Terra Cotta

Lignite ash. Studies concerning its use as a cheap glaze material for heavy clay products. W. G. WORCESTER. *Jour. Can. Ceram. Soc.*, **2**, 21 (1933).—The possibility of using lignite ash as a cheap glaze material was studied, it having been observed that in kilns fired with lignite (with forced draft) a considerable quantity of fine ash powder was conveyed upward into the crown of the kiln where it settled on the ware and eventually fused to a slag at the higher temperatures. The general results are as follows. Series A: This series, which carries ash, salt, and fluorspar, has proved in general the best, in that the shades and colors developed are attractive, and some of the blends give glazes which are good over a fairly wide heat range, the most favorable being between cones 4 and 7. Series B: In this series, ash, salt, and cryolite were used and resulted in russet-brown shades overcast with green, though at the higher temperatures the general shade is tan-brown, not unlike a medium fired albany slip glaze. The best heat range appears to lie between cones 5 and 7. Series C: This series consists of ash, red lead, and soda feldspar. In general the shade is a dark dead brown and unsatisfactory, and the temperatures necessary to produce the glazes are rather high, ranging from cones 8 to 10. Series D: In this series an investigation was made of lignite ash, free flint, and volcanic ash. The results are of interest in that the shades or colors produced are pleasing and, in the main, good. Most of them are russet-brown overcast with olive green. In the high silica area the general shade varies to a grayish green, and a greater degree of fusibility can be noted. The heat temperature ranges are cones 5 to 7. J.G.P.

Is terra sigillata a secret? CARL NUISSL. *Sprechsaal*, **67** [4], 45–46 (1934).—The engobe is applied on unfired bodies. The firing can be done in every kiln at an ordinary pottery temperature. The color of the finished coating depends on the firing color of the clay employed for the preparation of the engobe. It is possible to produce an engobe equivalent to a real sigillata coating from every highly plastic clay. M.V.K.

Steel tanks lined with nonabsorbent acid-resistant vitreous blocks. ANON. *Iron Age*, **132** [8], 25 (1933).—Details are given of the manufacture and use of a new ceramic product used in lining steel containers to make them acid resistant. A.K.

Effect of "souring" clay for roofing tile. ANON. *Brit. Clayworker*, **42** [502], 333 (1934).—The chief conclusions from a short study of one clay are as follows: (*a*) souring definitely increased the strength; (*b*) even one day's souring is advantageous; (*c*) souring for more than 4 days with the clay studied may not be worth the cost of longer storage. R.A.H.

Practical clayworking. X. ANON. *Brit. Clayworker*, **42** [502], 316–18 (1934).—A discussion on the manufacture of plaintile by the mechanical, semidry, and bat systems or processes is given. For Part IX see *Ceram. Abs.*, **13** [4], 89 (1934); for Part VIII see *ibid.*, **13** [3], 61 (1934). R.A.H.

Scientific and practical study of principal products for flooring in dwellings. X–XI. F. CHALAMEL. *Rev. mat. constr. trav. pub.*, No. 290, pp. 206–209*B*; No. 291, pp. 231–33*B* (1933).—The cleansing and maintenance of ceramic and other products used for flooring are discussed. For Part IX see *Ceram. Abs.*, **13** [3], 65 (1934). M.V.K.

Structure of ceramic pressed masses. RUD. JUCH. *Tonind.-Ztg.*, **58** [1], 3–4; [2], 14–17 (1934).—J. discusses reasons for the appearance of cracks and fissures in pressed clay products and ways to avoid them, including the vacuum press. M.V.K.

Attempts to de-air ceramic mixes. ROB. SELZER. *Tonind.-Ztg.*, **58** [3], 31 (1934).—S. describes an apparatus used with success since 1927 to de-air masses for the manufacture of socket pipes. Illustrated. M.V.K.

PATENTS

Ceramic acoustical material. RICHARD ERICSON, J. S. OFFUTT, AND J. R. PARSONS (United States Gypsum Co.). U. S. 1,948,878, Feb. 27, 1934. The process of producing a fired clay ceramic tile comprises first forming a deflocculated clay slip and adding thereto a tenacious foam and an agent capable of reflocculating the slip after a definite lapse of time, thereupon incorporating ligneous fibers with this mixture, placing the final mixture into a mold and letting it set up therein, drying the form, and then firing to harden it while at the same time firing out the added fibers which thereby produce interconnecting passages between the voids left by the foam.

Antislipping tread and method of making. EDWARD VAN DER PYL. U. S. 1,949,517, March 6, 1934.

Roofing tile. F. SLAVÍK. Czechoslo. P–3164–32; *Stavivo*, p. 206 (1933).—An auger-made tile has an opening in the middle rip. Above the line where the tile overlap the lower portion of the tile has a groove which runs to the opening mentioned. A nail put through this groove into the opening fixes the tile to the tiling lath. R.B.

Stoneware articles, etc. JEAN M. LARGE. Fr. 751,726, Sept. 8, 1933. Mg sands containing 28 to 32% $MgCO_3$ are used in making stoneware pipes, tile, etc., and in making champagne bottles. (*C.A.*)

White Wares

Factors for the calculation of ceramic and nonmetallic minerals. KENNETH G. SKINNER AND HEWITT WILSON. *Jour. Amer. Ceram. Soc.*, **17** [4], 93–115 (1934).

Effect of fineness of flint on vitrification of a ceramic body. C. W. PARMELEE AND W. R. MORGAN. *Ceram. Ind.*, **22** [3], 146–52 (1934).—Decreasing particle size of flint produces remarkable changes in vitrification behavior and strength of the body. Decrease in average diameter of the flint particles produced an approximately linear decrease in porosity of the fired body when intermediate average diameters were obtained by blending coarse and fine fractions of flint, thus giving a wide distribution of grain sizes of about the average diameter. A decrease in average diameter from 45 to 10 microns increased the modulus of rupture of the body from 4350 to 8000 lb. per sq. in. or 84% at cone 10. E.J.V.

Electric breakdown by heat of ceramic masses in relation to their thickness. C. SCHUSTERIUS. *Elektrowärme*, **4** [2], 38–41 (1934).—A material containing a high percentage of soapstone and a kaolin fire clay were investigated with regard to electric insulation as a function of the thickness of the layer and temperature. The former is a dense product; the latter has a porosity of 12% by volume. The breakdown curve is a straight line as a function of the thickness at all temperatures investigated (up to 900°C); the inclination against the abscissa is smaller, the higher the temperature and the more porous the material. The tests are described in detail. Bibliography. M.H.

Boric glaze for faience of the Slavutskii works. A. SHTEINBERG. *Keram. i Steklo*, **9** [9], 7 (1933).—The leadless glaze developed is of the following composition: frit: 33.65% borax, 11.25 chalk, 2.5 feldspar, 34.7 silica, 1.2 soda; the glaze: 6.5% raw kaolin, 6.5 fired kaolin, 87.0 frit. The chemical composition of the glaze is 57.34% SiO_2, 13.39 Al_2O_3, 0.16 TuO_3, 8.35 CaO, traces of MgO, 10.16 B_2O_3, 6.62 Na_2O, 2.21 K_2O. The Seger formula used is 0.529 CaO, 0.462 Al_2O_3, 3.372 SiO_2, 0.388 Na_2O, 0.004 F, 0.511 B_2O_3, 0.083 K_2O. Acidity is 3.01. M.V.K.

Using waste products of the production of aluminium chloride from kaolin in the ceramic industry. P. P. BUDNIKOFF AND M. YA. SOLOMONOV. *Keram. i Steklo*, **9** [9], 9 (1933).—During the production of $AlCl_3$ there is a large amount of waste product (on 100 tons of kaolin there are 60 tons of waste) composed of 88 to 96% SiO_2 in a finely dispersed state, 12 to 14% Al_2O_3, and traces of CaO. Attempts to employ it in the manufacture of ceramic ware are described. The faience mix was composed of 33.1% kaolin, 30.2 clay, 31.7 waste product, and 5 cullet. The molded ware was fired to 1280°; porosity of the body was 14 to 16%. The ware was glazed and fired to 1220°. The ware obtained was very white and without any defects. The glaze frit was 13.2% silica, 33.6 feldspar, 14.4 chalk, 18.4 lead litharge, 19.9 borax, and 1.5 kaolin; the glaze was 82.60 frit, 10.60 silica, and 6.80 kaolin. M.V.K.

Metasilicate, its detergent applications. T. K. CLEVELAND. *Soap*, **9**, 19–21 (1933).—C. discusses the use of

metasilicate in laundries and for glassware, households, and the metal industry. (*C.A.*)

Meissner porcelain for laboratory and plant. W. Funk. *Farben-Chem.*, **4**, 219–20 (1933).—Historical. (*C.A.*)

Chinaware and enamels. H. Stümbke. *Stavivo*, p. 213 (1933).—Illustrated. R.B.

PATENTS

Water closet. J. C. Duner (Duner Co.). U. S. 1,948,101, Feb. 20, 1934, and U. S. 1,949,246, Feb. 27, 1934.

Waterless cooking utensil. J. T. Morgan. U. S. 1,948,124, Feb. 20, 1934.

Water-closet bowl. F. T. Meyer (Meyer-Sniffen Co.). U. S. 1,948,970, Feb. 27, 1934.

Method and means to increase the electric insulating property of ceramics such as porcelain. Isidor Kitsee. (Mineralite Corp.). U. S. 1,949,311, Feb. 27, 1934.

Water closet. R. G. Howson. Brit. 405,636, Feb. 21, 1934.

Ceramic nozzles for spinning rayon, etc. Porzellanfabrik. Ph. Rosenthal & Co. A.-G. Ger. 577,562, June 1, 1933. A flux such as feldspar is mixed with the ceramic mass so that a glaze is formed on the nozzle during the firing without addition of a glaze powder. (*C.A.*)

Ceramic articles. Rudolf E. Heerd. Ger. 587,097, Oct. 30, 1933. A composition for making lustrous translucent ceramic articles comprises feldspar and subordinate amounts of kaolin and quartz, the latter having been previously fused and comminuted. The composition is molded and then given a single firing. (*C.A.*)

Equipment and Apparatus

Simple method for obtaining photographic records of time-settle curves with elutriation. G. Gollnow. *Jour. Amer. Ceram. Soc.*, **17** [4], 116 (1934).

Elutriation and microscopic examination of finely ground mineral grains. H. K. Shirrefs and A. F. Evans. *Proc. Australasian Inst. Mining Met.*, **88**, 423–77 (1932).—The Andrews elutriator is described and the method of use around a mill is discussed in detail. The effects of the following variables on the operation of the elutriator are discussed: kinetic effect, hindered settling effect, and time of separation. The briquetting and microscopic examination of finely ground mineral grains are described in detail. (*C.A.*)

Determination of particle size in grinding powders and their fractionation by continuous elutriation. C. Benedicks and P. E. Wretblad. *Jernkontorets Ann.*, **117**, 419–41 (1933).—Sedimentation methods for the fractionation of American Optical Co. grinding powders failed to give results comparable with micrometric measurements. Two causes were found to explain this: (1) the particles seemed to drop in swarms without classification, and (2) convection currents caused upward flow near the wall of the sedimentation tube and downward flow in the middle. A tube was constructed in which the liquid was given a temperature gradient so that a continuous increase of density downward was effected to prevent irregular currents. The particles were kept in suspension by an air-free 0.008 *M* $Na_4P_2O_7$ solution. By taking account of the variation in density and viscosity down the tube, Stokes' formula may be applied directly, and experiments show that the fractionation corresponds closely to micrometric measurements. Samples of 1 mg. suffice for a determination. Sedimentation to particles of 1μ and 2μ requires 10 and 2 days, respectively. To prepare uniform powders for dry-polishing Fe samples a continuous apparatus was devised in which liquid and powder were fed concurrently through a series of chambers of increasing diameter. This apparatus was found capable of fractionating 200 g. in 10 days and producing a uniform powder of 2 to 4μ and 3 to 6μ without any coarse particles. (*C.A.*)

Determination of pore size in ceramic bodies. Otto Bartsch. *Ber. deut. keram. Ges.*, **14** [12], 519–30 (1933).—An apparatus for the determination of average pore size and the amount of large pores is described and some results of measurements on refractory materials are given. E.J.V.

Measurement of permeability of porous media. R. D. Wyckoff, H. G. Botset, M. Muskat, and D. W. Reed. *Bull. Amer. Assn. Petroleum Geol.*, **18** [2], 161–90 (1934).—A detailed technique is described for the measurement of porous media by the use of either liquids or gases. Derivations of the formulas are given by which permeability may be computed from laboratory measurements. A convenient permeability unit, the darcy, is defined. Field measurements on the effective permeability of underground sands are discussed and appropriate formulas are derived, including expressions for liquid, gas, and gravity flows and composite artesian and gravity flows in steady state. Correction curves are given where the wells do not completely penetrate the producing sands. G.M.H.

Physical properties of platinum-rhodium alloys. J. S. Acken. *Bur. Stand. Jour. Research*, **12** [2], 249–58 (1934); R.P. 249.—A series of platinum-rhodium alloys containing approximately 10, 20, 40, 60, and 80% rhodium was prepared from pure platinum and pure rhodium. The melting point, hardness, density, electrical resistivity, temperature, coefficient of resistance, and thermal electromotive force against platinum were determined for each alloy. R.A.H.

Notes on heat-resisting metals. N. P. Inglis. *Jour. Soc. Glass Tech.*, **17** [68], 366–77 (1933).—The paper deals with developments and improvements in various metals to improve their resistance to heat. The phenomenon of "growth" in cast iron is briefly discussed and the addition of alloying elements on it is considered. Chromium is the most effective element in reducing "growth." The influence of silicon is discussed and the good heat resistance of low carbon-high silicon irons described. The heat resistance of steel is dealt with and chromium is shown to be the most effective element in reducing corrosion at high temperatures under both oxidizing and

sulfurizing conditions. The utility of the chromium-nickel austenitic steels is referred to and, particularly, the benefit conferred by the addition to the 18/8 type of titanium. The extreme susceptibility of the nichrome class of alloy to gases containing sulfur is shown, and the effect of the addition of aluminium to these alloys is dealt with. Experimental results are quoted, showing the great increase in resistance to sulfur-containing gases obtained when aluminium is added to the nichrome class of alloy. A.J.M.

Heat-resisting chromium-nickel-iron alloys for furnace construction. ANON. *Metallurgia*, **9** [49], 6 (1933).—This is a discussion of a paper by L. J. Stanberry (*Ceram. Abs.*, **13** [3], 67 (1934)). M.V.K.

Maximum capacity of heating elements. K. MERTENS. *Elektrowärme*, **3** [12], 364–65 (1933).—The calculation of dimensions of heating elements is explained. Charts are given for current, voltage, diameter of elements as a function of the temperature, and calories required in the furnace. M.H.

Resistance alloy for temperatures up to 1300°C. A. GRUNERT, W. HESSENBRUCH, AND K. RUF. *Elektrowärme*, **3** [7a], 208–12 (1933).—The new resistance element is based on Cr-Fe alloys in which the Fe used is pure and free of C; the material under the name "Megapyr" is composed of 65% Fe, 30 Cr, and 5 Al; it is very resistant to S-containing furnace gases; its specific gravity is 7.1 g./cm.^{3} as against 8.4 for Cr-Ni alloys. Permissible load in watts per cm.^{2} surface is considerably higher than for Cr-Ni and at 1350°C is still 0.5 where the other can no longer be used. A description of the handling and forming of heating spirals is given. Bibliography. See also *Ceram. Abs.*, **12** [10–11], 389–90 (1933). M.H.

Effect of de-airing stiff-mud clay bodies by evacuation. J. W. AKAM. *Jour. Can. Ceram. Soc.*, **2**, 18 (1933).—This is the original reference; for abstract see *Ceram. Abs.*, **13** [4], 89 (1934). J.G.P.

New kick wheel for potters. S. C. STILLMAN. *Ceram. Ind.*, **22** [3], 166 (1934).—The Alfred potter's wheel is built on a sturdy wooden frame, is very compact, weighs only a little over 100 lb., is readily portable, and is operated by means of gears driven by a foot pedal. E.J.V.

A boiler-house Orsat set. KARL MUNZER. *Eng. Progress*, **15** [1], 4–5 (1934).—The construction and use of a particularly rugged gas analysis set designed for plant use is described. Illustrated. J.L.G.

New optical pyrometer. PYROMETRIC INSTRUMENT CO. *Better Enameling*, **5** [2], 27 (1934); *Fuels & Fur.*, **12** [1], 31 (1934).—A new self-contained optical pyrometer is announced with three separate direct-reading scales, 1400 to 2000°F, 1800 to 3400°F, and 2200 to 3600°F. Illustrated. E.J.V.

Simplification of machinery effects savings in silica plant. E. M. UNDERWOOD. *Pit & Quarry*, **26** [8], 26–27 (1934).—A continuous feed and discharge ball mill, Silex-lined, in closed circuit with an air separator has replaced numerous batch mills for grinding silica at the Potters Mining & Milling Co., East Liverpool, Ohio. A detailed description of the plant equipment and its operation is given. Illustrated. E.J.V.

Laboratory apparatus for the mechanical sampling of coal. A. DAWE AND N. M. POTTER. *Fuel Sci. Practice*, **12** [9], 313–19 (1933).—A "Cascade" sampler is described which automatically mixes, cones, and divides coal into a number of true samples. Illustrated. F.G.H.

Grinding rolls *vs.* dry pans. D. A. MOULTON. *Brick Clay Rec.*, **84** [2], 50–51 (1934). E.J.V.

Methods of preparing clay. O. LEPNAER. *Tonind.-Ztg.*, **57** [83], 978–79 (1933).—This paper deals mainly with the construction of crushing mills and extruding machines used in manufacturing common brick and tile. It is proposed to replace the auger by several rolls of special shape. W.M.C.

Study of crushing brittle solids. W. F. CAREY AND C. H. BOSANQUET. *Jour. Soc. Glass Tech.*, **17** [68], 384–410 (1933).—Under free crushing conditions, whether the load be applied by simple crushing, shear, or impact, it is found that homogeneous brittle solids break down with a constant fracture pattern which is independent of the size of the original specimen. This law must be interpreted statistically, since wide variations will be found in the behavior of individual particles. It thus appears that the minimum work required to crush a powder depends on the product of (1) the constant for the material, (2) the weight of the material crushed, (3) the logarithm of the total mean reduction $= \log \frac{\text{the mean original size}}{\text{the mean final size}}$. To crush coal and anhydrite through a 10:1 reduction ratio involves an energy consumption of 0.05 and 0.15 kw.-hr./T., respectively. Material of $^1/_2$-in. size crushed to 200-mesh involves a mean reduction ratio of about 100:1, and the work necessary is thus 0.1 kw.-hr./T. for coal and 0.3 kw.-hr./T. for anhydrite. Values of a similar order have been obtained for other materials, and indicate that industrial crushing requires about 100 times as much energy as that theoretically necessary. This means that the industrial methods of crushing are very wasteful in energy compared with the process adopted by a laborer crushing stones. Industrially this information is perhaps of little value, but it gives a basis on which to define the efficiency of other grinding processes in which the loading conditions of the individual particles are difficult to define. A.J.M.

Laboratory type of electric muffle furnace. COOLEY ELECTRIC FURNACE CO. *Fuels & Fur.*, **12** [1], 32 (1934).—Among uses for these furnaces are experimental testing, enameling, and fusions. E.J.V.

High-frequency induction furnaces for melting. H. BECKMANN. *A E G Mitt.*, pp. 111–15 (1933).—The operating principles of industrial induction furnaces are described. Data are given for the selection of a suitable frequency. For a power consumption below 40 kw. 10,000 to 20,000 cycles per second are recommended; for furnaces operating above 300 kw., 350 to 1000 cycles. Frequency determines the type of motor-generator set to be used. Construction details of the furnace proper are discussed and typical condenser and switchboard arrangements illustrated. (*C.A.*)

Investigation into stock brick drying. ANON. *Brit. Clayworker*, **42** [502], 325–26 (1934).—The successful application to plant practice of laboratory results obtained on a difficult drying clay by the Bodin Gaillard apparatus is discussed. R.A.H.

Investigations on an artificial drying installation for

brick. E. SCHONDORFF. *Tonind.-Ztg.*, **58** [9], 96–101 (1934).—An account of experiments on the artificial drying of brick is given. Diagrams illustrate the paper. M.V.K.

Losses in drying and firing brick and tile. B. HELAN. *Stavivo*, p. 126 (1933).—To evaporate 1 kg. of water in the drier in practice, 900 to 1500 cal. are needed. That means that for drying 1000 brick of 290 x 140 x 65 mm. 0.9 to 1.5 million calories (200 to 300 kg. of bituminous coal or 150 to 250 kg. of coal high in carbon) are necessary. To evaporate 1 kg. of water from the ware in sheds 600 m^3 of air are needed. If drying on the kiln 100 $m.^3$, in driers about 30 $m.^3$, and in driers with multiple air heating 20 $m.^3$ or less are needed. Low drier output is often caused by insufficient air circulation. R.B.

New device for drying structural clay products. A. MARŠÁLEK. *Stavivo*, p. 36 (1933).—The driers used at Flensburg, Celle, and other German plants are described. Several chambers are built to form an annular drier and the ware is dried with warm, moist air at the beginning and with hot, dry air at the end of the operation. Illustrated. R.B.

Experiences from drier practice. JOSEF PÖSSNER. *Stavivo*, p. 124 (1933).—Driers with multiple heating of the circulating air give products of better quality and have a three-fold output. R.B.

BOOK

Correction Tables for Use with Platinum Resistance Thermometers. G. S. CALLENDAR AND F. E. HOARE. Longmans, Green and Co., New York, 1933. 12 pp. Reviewed in *Jour. Amer. Chem. Soc.*, **56** [2], 496 (1934). F.G.H.

PATENTS

Apparatus for producing rock wool products. E. R. POWELL (Banner Rock Corp.). U. S. 1,948,395, Feb. 20, 1934.

New drying device for structural brick and tile. JOSEF PÖSSNER. Czechoslo. 40,911; *Stavivo*, p. 68 (1933).—This drier uses multiple heating of the drying air. The same air is circulated through the drier in a constant quantity, this air being heated moderately and continuously and transmitting the heat immediately to the goods. As only small quantities of air leave the system, only small amounts of heat can be lost. This is the device's advantage when compared with any drier with single air heating. Another disadvantage of these drier systems with single heating of air is the large power consumption of the fan if the systems are operated at lower temperatures than those for which they are computed. To maintain the output at lower temperatures the number of revolutions of the fans must be proportionally increased. R.B.

Firing and drying heavy clay products. FRANTIŠEK BEZINEK. Czechoslo. P–7172, Sept. 16, 1930; *Cement a beton*, p. 22 (1933).—In the kiln room a partition is erected. The ware is set around this partition and finally covered so as to allow the waste gases to pass over it. R.B.

High-temperature electric furnace. GOTTHARDWERKE A.-G. FÜR ELEKTROCHEMISCHE INDUSTRIE AND ARTURO PAOLONI. Swiss 161,514, July 17, 1933. An electric furnace for temperatures of 1400 to 1900° is described. The chambers are built of SiC. (*C.A.*)

Kilns, Furnaces, Fuels, and Combustion

Electric heating in the glass and ceramic industries. KNOOPS. *Elektrowärme*, **3** [8], 249–50 (1933).—The development and present designs of kilns, muffles, and glazing and enameling furnaces with electric heating are reviewed and operating data are given. An annealing furnace for bottles, with a width of 1.3 m., height 0.6 m., and length 30 m., requires 17 kw.-hr. per ton for 500 kg. material per hr. if the material enters the furnace at 500° C. The following energy consumptions are given: for annealing glass dishes 50 to 55 kw.-hr./ton, milk bottles 41 to 42, and mineral water bottles 15 to 18. Firing colors on china dishes requires about 0.4 to 0.5 kw.-hr. per kg. for a furnace capacity of 2000 to 3000 dozen plates per day. M.H.

Firing brick and tile in annular kiln. A. CHMELÍČEK. *Stavivo*, p. 167 (1933).—The mechanical stoker "Palič" invented by Chmelíček is described. Its advantages are simple maintenance and low power consumption. Illustrated. R.B.

The flame and the firing of tank furnaces. ANON. *Verre & Silicates Ind.*, **5** [1], 6–8 (1934).—After a theoretical discussion of the process of combustion and the exchange of calories between the flame and the glass tank, practical considerations for obtaining best results are enumerated, *viz.*, the flame must be long, hot, well supplied, and constant and must have a considerable capability of emission. The loss in calories due to smoke must be reduced to a minimum. M.V.K.

Recuperation for industrial furnaces. S. N. BRAYSHAW. *Mech. World*, **93** [2413], 317–19 (1933).—It is not economical to recover all the heat from flue gases, since it is cheaper to use some of the heat to create draft than to install a fan for removing cooled gas. Size of the recuperator is important, since the larger the recuperator the more heat intended for recovery will be dissipated. Illustrated. E.J.V.

Heat losses from industrial furnaces. S. N. BRAYSHAW. *Mech. World*, **93** [2412], 286–87 (1933).—Smoothness of the outer surface retards radiation but increases loss by convection. Radiation is not affected by the position of the surface, but the loss by convection is much greater on a horizontal surface facing upward than on a similar surface facing downward. Convection currents can be interrupted by a suitable arrangement of the furnace framing, but this may increase radiation surface. Illustrated. E.J.V.

Modern resistance furnaces in industry. E. SCHMIDT. *A E G Mitt.*, pp. 116–22 (1933).—Uniform heat distribution, accurate temperature control without time lag, a minimum of supervision, close control of atmospheric

conditions and a long life are advantages of modern resistance furnaces which should be included in consideration of their operating costs. Various types of resistance furnaces are described and examples are given for the practical application of each type. (*C.A.*)

Lighting the fires in annular kiln perilous. A. Chmelíček. *Stavivo*, p. 219 (1933).—When the fires in ceramic kilns are lighted deadly carbon monoxide gas may form. C. describes fatal accidents resulting from this gas formation. R.B.

Steam-atomizing burner. Anon. *Iron Age*, **132** [4], 27 (1933).—A new steam-atomizing burner is described designed to handle fuels such as heavy oil, tar, pitch, and cold sludge. A.K.

Tests on stack masonry constructed of wedge-shaped brick. Fr. Klokner. *Stavivo*, p.138 (1933).—Calculations of stack constructions are published. Illustrated. R.B.

Determining heating values of fuels from elementary analyses. Fritz Schuster. *Brennstoff-Chemie*, **15** [3], 45–46 (1934).—The heat value formula of Grumell and Davies (*Ceram. Abs.*, **13** [4], 97 (1934)) gives good results for only a limited group of fuels, but is not generally applicable. It is surpassed by older equations (Vondracek, Schuster) and by three new formulas in accuracy and in range of applicability. E.J.V.

Progress in fuels. T. A. Mangelsdorf and F. B. Broughton. *Fuels & Steam Power*, **55**, No. 1 (1933); abstracted in *Mech. Eng.*, **55** [10], 644 (1933).—This report covers fuels and fuel utilization, natural fuel production, coal carbonization and gas manufacture, industrial furnaces and kilns, and smoke and dust abatement. Many references and a supplementary bibliography are given. F.G.H.

Petrographic and chemical investigations relating to the origin of coal. E. Berl and H. Keller. *Liebigs Ann. Chem.*, **501**, 84–106 (1933); abstracted in *Fuel Sci. Practice*, **12** [9], 325 (1933). F.G.H.

Characteristics of pulverized fuels. H. Heywood. *Jour. Inst. Fuel*, **6** [4], 241 (1933); abstracted in *Fuel Sci. Practice*, **12** [7], 254 (1933). F.G.H.

Rational examination of coal. W. Francis. *Jour. Inst. Fuel*, **6** [6], 301 (1933); abstracted in *Fuel Sci. Practice*, **12** [8], 289 (1933). F.G.H.

Tube method for determining the fusion temperature of coal ash. A. Dawe. *Fuel Sci. Practice*, **12** [8], 271–75 (1933).—Illustrated. F.G.H.

Determination of ash in washed coal. T. Horiuchi. *Jour. Fuel Soc.* [Japan], **12** [6], 72 (1933); abstracted in *Fuel Sci. Practice*, **12** [8], 290 (1933). F.G.H.

Removal of acid-sulfur compounds from combustion gases. D. Brownlie. *Steam Engr.*, **2** [9], 517 (1933); abstracted in *Fuel Sci. Practice*, **12** [10], 361 (1933). F.G.H.

Measurement of the true gas temperatures. S. Uchida. *Jour. Fuel Soc.* [Japan], **12** [8], 97 (1933); abstracted in *Fuel Sci. Practice*, **12** [10], 362 (1933). F.G.H.

Rate of reduction of carbon dioxide by graphite. M. A. Mayers. *Jour. Amer. Chem. Soc.*, **56** [1], 70–76 (1934). F.G.H.

BOOK

British Standard Specification for the Sampling and Analysis of Coke, No. 496, July, 1933. British Standards Institution. Price 2s. *Fuel Sci. Practice*, **12** [8], 290 (1933). F.G.H.

PATENTS

Kiln apparatus. J. J. Schmidt (Frederick Iron and Steel Co.). U. S. 1,947,496, Feb. 20, 1934. In combination, a kiln has a plurality of combustion chambers, a plurality of groups of automatic firing means for cooperating with selected groups of combustion chambers, each combustion chamber having fuel- and air-intake connection and each firing means having fuel- and air-discharge connections for detachable connection with the intake connections of the combustion chambers, and means for progressively shifting the groups of firing means along the kiln from one group of combustion chambers to another.

Method and kiln for producing refractory brick. A. B. Agnew. U. S. 1,950,375, March 13, 1934.

Tunnel kiln. Václav Veselík. Czechoslo. P–9792–30, Dec. 18, 1930; *Stavivo*, p. 150 (1933).—A drying chamber is separated from the kiln by a door and a cooling zone. R.B.

Tunnel kiln. Holdingges. für keramische Werte. Czechoslo. Pat. application, Jan. 27, 1931.—The kiln has shaft furnaces even in the preheating zone. R.B.

Tunnel kiln. Joseph Daniels (Heinrich Koppers A.-G.). Ger. 573,854, April 6, 1933; addition to 509,787, *Ceram. Abs.*, **10** [5], 379 (1931). (*C.A.*)

Kilns. Franz Skaupy. Ger. 574,717, April 19, 1933. High-temperature kilns, furnaces, etc., are coated with a mixture of granular Al_2O_3, MgO, and ZrO_2 to prevent loss of heat by radiation. (*C.A.*)

Gas-heated tunnel kiln. C. Otto & Co. Ges. Ger. 579,358, June 24, 1933. Details are given of a burner to which weak heating gas or strong gas diluted with combustion gases can be supplied at will. (*C.A.*).

Geology

Chemical composition of the earth. C. J. van Nieuwenburg. *Chem. Weekblad*, **30** [15], 278–80 (1933).—The distribution of elements in the earth's crust is given as consisting to 99.7% of O (0.5%), Si, Al, Fe, Ca, Na, K, Mg, H, Ti, Cl, P (0.001%) in the order named, and the remainder of the other elements from Mn (9×10^{-4}%) to Ra (1×10^{-13}%). M.H.

Formulas for calculating stratigraphic thickness exposed between two dips. E. L. Ickes. *Bull. Amer. Assn. Petroleum Geol.*, **18** [1], 139–42 (1934). G.M.H.

Employing lestivarite, plagioclasite, and porphyry in ceramic products. V. T. Popova. *Keram. i Steklo*, **9** [10], 20–23 (1933).—P. gives an account of investigations made on lestivarite, plagioclasite, and porphyry with regard to their use in the production of ceramic ware and comparative tests of mixes containing these materials with those containing potassium feldspar. All mixes have approximately the same shrinkage. Feldspar mixes sinter more rapidly than plagioclasite mixes, but lestivarite mixes sinter sooner than feldspar mixes; the sintering of porphyry mixes is similar to that of those containing feldspar. The resistance to breaking and thermal resistance

are the same. The deformation of lestivarite mixes is greater than that of feldspar mixes; it is lower in porphyry mixes when they are fired to cones 11, 13, and 14. Lestivarite and porphyry bodies have a grayish or yellowish color depending on the atmosphere and firing temperature; plagioclasite bodies are white. Lestivarite glazes have a lower fusing temperature than feldspar glazes. The composition of plagioclasite, lestivarite, and porphyry glazes is given. M.V.K.

Composition of dolomite. E. Onorato. *Periodico mineral.*, **1**, 216–20(1930); *Neues Jahrb. Mineral. Geol.* [Referate I], 222 (1932).—Dolomite is a definite double compound, $CaCO_3 \cdot MgCO_3$, as shown by crystal-structure data. (*C.A.*)

Crystal structure of silicates. E. Schiebold. *Ergebnisse exakt. Naturw.*, **11**, 352–434 (1932).—Mineralogical relationships of structural types are considered. The structures and physical constants of the most important rock-forming silicates are tabulated. (*C.A.*)

Difference between a mica and a clay as to the orientation of crystals depositing on them. L. Royer. *Compt. rend.*, **196**, 552–54 (1933).—The parameters of the micas, clays, etc., are approximately the same as shown by X-rays. The geometric relations are the same, but the physical conditions are different. The micas, hard micas, and chlorides are made up of parallel layers (001), each being charged negatively. In talc, kaolin, and pyrophyllite, the plates are neutral. Two factors in the mutual orientation are important, the geometric distribution of the lines or nodes in the lattice, and the polarity of the particles. (*C.A.*)

Titanium and zirconium. F. H. Driggs. *Mineral Ind.*, **41**, 517–24 (1932).—The Ti industry gained in 1932. Technology and consumption are discussed. (*C.A.*)

Chemical analysis of clays with special reference to clay fractions of soils. R. C. Groves. *Jour. Agric. Sci.*, **23**, 519–26 (1933).—Decomposition of clays with a mixture of HCl, HNO_3, and H_2SO_4 for the determination of SiO_2 yields results in close agreement with those obtained by the customary Na_2CO_3 fusion (*A*) process. In a few exceptional cases treatment with HF reveals the presence of foreign matter in the SiO_2 residue. Such samples must be analyzed by method *A*. In the acid extract of clay, Fe and Ti may be determined by the cupferron method. (*B.C.A.*)

Fixation of silica by colloidal clay. A. Demolon and E. Bastisse. *Ann. agron.*, **3**, 83–90 (1933).—Clay, depending on its colloidal nature, may fix the silicic ion from soluble silicates under moisture conditions precluding the precipitation of silica as a hydrogel. The fixation of 2 ions of an alkaline silicate is effected independently. The amount of silica and the adsorptive capacity of the clay are proportional. Diminution of hydration and feeble acidity destroy the complex. (*C.A.*)

Use of Wolf's centrifuge in the mechanical analysis of soils. E. Peyrot. *Ann. chim. Appl.*, **23**, 435–38 (1933).—As used by Wolf, Schlatter, and Jung, this centrifuge gives erroneous results. A modified procedure is described. (*B.C.A.*)

Development possibilities along Tennessee and Tombigbee Rivers. William L. Smith. *Manufacturers Rec.*, **103** [3], 64 (1934).—The abundance of bauxite, high-grade kaolin and plastic clays, and outcropping of gypsum in the Tenn. Valley are cited as possibilities of the development of mineral resources. E.J.V.

Evaluation of sand deposits. E. Wayne Galliher. *Rock Prod.*, **37** [3], 50–51 (1934).—The mineral examination of a sand is an essential factor in the evaluation of the deposit. Calif. sands often contain compound mineral grains which must be removed by grinding, magnetic separation, and flotation methods to make them available as glass sands. Several problems are being solved by the application of mineralogy to sand technology. Illustrated. E.J.V.

Feldspar. Hugh S. Spence. *Jour. Can. Ceram. Soc.*, **2**, 62 (1933).—Statistics on world production and consumption in Canada are given. The feldspar mines of Canada are described and the details of milling practice are discussed together with quality standards. J.G.P.

Origin of surface clays of southern Ontario. J. F. Wright. *Jour. Can. Ceram. Soc.*, **2**, 61 (1933). J.G.P.

Quartzite from Nova Scotia. L. H. Cole and J. F. McMahon. *Jour. Can. Ceram. Soc.*, **2**, 64 (1933).—A deposit of quartzite from Sunnybrae, Nova Scotia, was sampled and tested as a possible raw material for the manufacture of silica brick. Although this material is not so high in silica as is desirable and although high in alumina, it converts readily to cristobalite and could be used for the manufacture of silica brick. J.G.P.

Possible industrial application for bentonite. Hugh S. Spence and Margaret Light. *Jour. Can. Ceram. Soc.*, **2**, 63 (1933).—This report supplements *Mines Branch Rept.*, No. 626, on this subject which was published in 1924 and includes new information. J.G.P.

Canada's mineral industry has bright outlook. W. A. Gordon. *Can. Mining Jour.*, **55** [2], 45–46 (1934). G.M.H.

Facts and figures from Canadian mines in 1933. W. H. Losee. *Can. Mining Jour.*, **55** [2], 49–54 (1934). G.M.H.

Review of the mineral industry of British Columbia in 1933. H. G. Nichols. *Can. Mining Jour.*, **55** [2], 68–73 (1934). G.M.H.

Quebec's mineral industry during 1933. A. O. Dufresne. *Can. Mining Jour.*, **55** [2], 63–65 (1934). G.M.H.

Corundum deposits of the Kazakian Steppe (Semiz-Bugu and Kalak-tas). M. Rusakov and N. Nakovnik. *Trans. Geol. Prospecting Service U.S.S.R.*, **87**, 1–43 (1932); *Neues Jahrb. Mineral. Geol.* [Referate 2], 469–70 (1932).—Analyses of corundum-rich rocks are included. (*C.A.*)

Occurrence *in situ* of corundum-bearing rocks in British Malaya. E. S. Wilbourn. *De Mijning*, **12**, 170–76 (1931); *Neues Jahrb. Mineral. Geol.* [Referate 2], 468–69 (1932).—Analyses of corundum-rich masses are given. (*C.A.*)

Utilization of rocks and minerals of Austria. B. Granigg. *Montan. Rundschau*, **24** [20], 7–9 (1932).—Magnetic treatment of various feldspar-containing rocks reduces the Fe_2O_3 content to 0.4% or less. The nonmagnetic residue is suitable for use in the manufacture of ceramics. See also *Ceram. Abs.*, **11** [8], 448 (1932). (*C.A.*)

Notes on refractory clays of the Andenne basin. A.

CLAUSSET. *Verre & Silicates Ind.*, **5** [1], 2–6 (1934).—After discussing the composition and properties of refractory clays of the Andenne basin, C. describes experiments dealing with (1) their plasticity, (2) shrinkage and density, (3) cohesion after firing, and (4) temperature of softening and failure under load. M.V.K.

Popasnyanskii lay. V. V. GONCHAROV AND R. KASHTELYAN. *Keram. i Steklo*, **9** [10], 17–19 (1933).—Details on the ceramic properties and chemical composition and tests made with Popasnyanskii clays are given. The clay has a high silica and alkali content and low loss on ignition. The contents in SO_3 and Fe_2O_3 are low. M.V.K.

BOOKS AND BULLETIN

Determination of Feldspars in Thin Sections. KARL CHUDOBA. Translated by W. Q. Kennedy. Thomas Murby and Co., London. 6s 6d, net. Reviewed in *Can. Mining Jour.*, **55** [2], 89 (1934). G.M.H.

Chromite deposits of the eastern townships of the province of Quebec. BERTRAND T. DENIS. *Ann. Rept. Quebec Bur. Mines* [Part D], 106 pp. (1931).—The chemical composition and mode of origin of Quebec chromite are discussed. Chromite was a primary constituent of the magma and accumulated by crystal settling. During final consolidation some of the chromite was redistributed by solution and redeposition, but this was of little importance in ore formation. (*C.A.*)

Abstracts of current articles on geophysical prospecting. F. W. LEE. *Bur. Mines Periodical Service Rept.*, GA 56, 28 pp. 10¢. See also *Ceram. Abs.*, **13** [4], 100 (1934). R.A.H.

Chemistry and Physics

Note on phase equilibria in the system Na_2O–TiO_2. EDWARD W. WASHBURN AND ELMER N. BUNTING. *Bur. Stand. Jour. Research*, **12** [2], 239 (1934); R.P. 648.—The following compounds are formed in the binary system Na_2O–TiO_2: Na_2TiO_3 melting at 1030°C, $Na_2Ti_3O_7$ melting at 985°C, and $Na_2Ti_3O_7$ melting at 1128°C. R.A.H.

Sedimentation method for determining the particle size of finely divided materials. DANA L. BISHOP. *Bur. Stand. Jour. Research*, **12** [2], 173–83 (1934); R.P. 642.—B. reports a comparison between a sedimentation method of determining particle-size distribution and a microscopic method and some data on hydrated lime. Glass spherules were prepared from Pyrex brand glass and fractionated so that most of the particles had a diameter within 2 microns of the average diameter of the fraction. These particles were then dispersed in a liquid and weighed as they settled out of the suspension with an automatic weighing device. From this sedimentation record the particle-size distribution was calculated. The same sample was used to determine the particle-size distribution by measuring the diameters of several hundred particles with a microscope. The microscopic and sedimentation measurements showed similarly shaped distribution curves but there was some variation between them. R.A.H.

Microscopic and chemical investigation of two clays. F. K. SCHLÜNZ. *Chem. Erde*, **8**, 167–85 (1933).—A diluvial and a tertiary clay were separated by settling in water into 1, 1 to 5.5, 5.5 to 12, 12 to 30, and 30μ fractions. These were examined microscopically, the percentage of each mineral was estimated, and the fractions were analyzed. Quartz and feldspar increased with increasing particle size, while muscovite decreased. Chemically, SiO_2, CaO, Na_2O, K_2O, and CO_2 increased, while Al_2O_3 and H_2O decreased. (*C.A.*)

Physical properties of colloidal clays. C. LA ROTONDA. *Z. Pflanzenernähr. Düngung Bodenk.*, **30A**, 269–84 (1933).—Three colloidal clays were examined for reaction, viscosity conductance, and coagulation in the presence of varying amounts of alkalis. The relative action of the alkalis when used as dispersing agents was NaOH > KOH > NH_4OH > $Ca(OH)_2$ > $Ba(OH)_2$. A p_H of 7 was obtained with 10 milliequivalents of NaOH, about 14 milliequivalents of KOH, 16 of $Ca(OH)_2$, and 17 of $Ba(OH)_2$. The relative viscosity of a Hangelar clay was decreased from 1.081 to 1.051 with increased amounts of NaOH up to 10 milliequivalents, after which it increased to 1.082 with 20 milliequivalents. (*C.A.*)

Influence of anions on the flocculation of colloidal white clay by potassium salts. A. DEMOLON AND E. BASTISSE. *Compt. rend.*, **195**, 790–92 (1932).—K phosphate, arsenate, molybdate, ferrocyanide, borate, silicate, citrate, tartrate, etc., raise the flocculation values at constant p_H. An optimum peptizing OH-ion concentration exists. It depends on the base used. Kaolin shows no such optimum value. Fe_2O_3 increases the flocculation threshold value. The clay is always negatively charged. (*C.A.*)

Combination of calcium in the system lime–titanium dioxide and in lime–silicon dioxide–titanium dioxide. ISIDRO PARGA-PONDAL AND KARL BERGT. *Anales soc. espaü. fis. quím.*, **31**, 623–37 (1933).—In the system CaO–TiO_2, if CaO is present in sufficient quantity or in excess, $CaO \cdot TiO_2$ forms up to 1300°, but at 1400° $3CaO \cdot TiO_2$ is formed. Melting corresponding raw mixtures in the oxy-acetylene flame indicates the existence of titanates rich in CaO. In the system CaO–SiO_2–TiO_2, with gradual substitution of SiO_2 by TiO_2 the CaO combination at first rises, then falls. At low temperatures and low TiO_2 contents the CaO combination is facilitated. There is no evidence of formation of double compounds between Ca silicates and Ca titanates. (*C.A.*)

Gelation of silicic acid. MATA PRASAD. *Jour. Indian Chem. Soc.* (Prafulla Chandra Ray Commemoration Vol.), pp. 119–23 (1933).—Silicic acid gels made by the action of an acid on Na silicate first pass through a sol stage. The sol particles are negative in alkaline and feebly acid solutions and positive in acid solutions. The electrolytes present coagulate the sol, causing increased hydration and increased viscosity. The setting time of the gels depends upon the concentration of the acid and the silica content of the mixture. Neutral or slightly acidic mixtures set

in a minimum time. Alkaline mixtures give opaque gels and acidic mixtures give translucent gels. Other characteristics of silicic acid gels are summarized. (*C.A.*)

Viscosity of the silicic acid gel-forming mixtures. MATA PRASAD, S. M. MEHTA, AND J. B. DESAI. *Jour. Phys. Chem.*, **36**, 1384–90 (1932).—When silicic acid gels form in an alkaline medium the initial rate of increase of viscosity is more rapid and the acceleration of increase of viscosity is smaller than when the gels form from the same concentrations of SiO_2 in acid media. Increase in concentration of acid decreases the rate of increase in viscosity. Increase in the concentration of alkali increases the rate of increase of viscosity. These facts may be explained by assuming that the initial increase in viscosity is due to the number of small colloidal particles formed and the later increase in viscosity is due to the increased hydration of the particles. (*C.A.*)

Influence of nonelectrolytes on the viscosity of silicic acid gel-forming mixtures. MATA PRASAD, S. M. MEHTA, AND J. B. DESAI. *Jour. Phys. Chem.*, **36**, 1391–1400 (1932).—Further experiment confirms the coagulating effect on alcohols of 4 and 5% SiO_2 in alkaline solutions. The alcohols used were MeOH, EtOH, and PrOH. The rate of increase in viscosity increases with the concentration of alcohol. Small concentrations of alcohol in feebly acidic solutions also promote coagulation. The optimum concentration for coagulation is about 0.5 cc. of EtOH in 40 cc. of a mixture containing 4% SiO_2 and 0.55 *N* AcOH. More than 2 cc. of EtOH in this mixture is protective. See also *Ceram. Abs.*, **11** [7], 429 (1932). (*C.A.*)

Crystallized boron. L. HACKSPILL, A. STIEBER, AND R. HOCART. *Compt. rend.*, **193**, 776–78 (1931).—Pure B was obtained by passing a high-frequency spark through a mixture of H_2 and BCl_3 vapor. Spectrum analysis showed it to be crystalline and probably of a hexagonal system. (*C.A.*)

Recovery of potassium and aluminum salts and silicic acid from natural alkali-clay silicates. B. GRANIGG. *Montan. Rundschau*, **25** [21], 1–9 (1933).—The literature on methods of production of potash and Al salts is reviewed, and cost calculations are made for the various raw materials found in quantity in various countries. (*C.A.*)

Rôle of aluminum in the chemical structure of feldspars. J. MARTINET. *Rev. gén. sci.*, **43**, 702–705 (1932).—A diagram proposed to show the constitution of anorthite is similar to one suggested for quartz, but every alternate Si has been replaced by Al, because the mineral should be considered as an aluminosilicate and not as a double silicate. If only every 4th Si is replaced by Al, the charge of the network is only half as large and the meshes will contain univalent ions, *e.g.*, Na, K, instead of bivalent Ca ions. The structure of orthoclase and albite will therefore be strictly comparable to that of anorthite. These diagrams agree with Vernadskiĭ's ideas regarding aluminosilicates and with the electronic theory of valence, and have the advantage of furnishing a satisfactory explanation of known properties of feldspars. (*C.A.*)

Various methods of determination of aluminum as oxide. TOSHIO KŌZU. *Jour. Chem. Soc. Japan*, **54**, 653–81 (1933).—For precipitating $Al(OH)_3$ in a condition in which it is easily filtered and washed, the methods can be ranked as follows: (1) Stock's method, adding a mixture of KI and KIO_3, (2) Chancel's method, adding $Na_2S_2O_3$ and then heating, (3) blowing CO_2 into Na aluminate, (4) treatment with NH_3 in the presence of NH_4Cl, and (5) treatment with NH_3 in the presence of NH_4Cl and $Na_2B_4O_7$. (*C.A.*)

Thermal decomposition of natural hydroxides of aluminum and of trivalent iron. A contribution to the question of reactions in the solid state. HERMANN SCHWIERSCH. *Chem. Erde*, **8**, 252–315 (1933).—The object of this work was to determine the lowest temperature at which the hydroxide gave off water continuously to form the oxide, and also to determine, by X-rays and the *ns*, the form of the oxide produced. Diaspore, orthorhombic AlO(OH), gave up H_2O above 340° to give corundum (hexagonal Al_2O_3). Hydrargillite, $Al(OH)_3$, started to lose H_2O at about 150° to form böhmite, γ-AlO(OH), which continued slowly to lose H_2O to give γ-Al_2O_3. However, better crystallized böhmite was formed by heating hydrargillite to 300° in steam at 22 atmospheres. This, like diaspore, only gave off H_2O above 340°. Goethite, orthorhombic FeO(OH), started to lose H_2O about 220° to give hematite (hexagonal Fe_2O_3). Ruby-mica, γ-FeO(OH), started to give off H_2O about 195° to give γ-Fe_2O_3, which changed to α-Fe_2O_3. Limonite had an even lower but indefinite decomposition point. Numerous tables, graphs, and an extensive bibliography are included. (*C.A.*)

ζ-Al_2O_3 is identical with γ-Al_2O_3. D. BELIANKIN. *Centr. Mineral. Geol.*, **A**, 300–302 (1933).—The physical constants such as density, *n*, and a_0 given by Barlett (*Ceram. Abs.*, **11** [8], 468 (1932)) for the so-called ζ-Al_2O_3 check those calculated for pure γ-Al_2O_3. ζ-Al_2O_3 is not a new form, but is merely well crystallized γ-Al_2O_3. (*C.A.*)

Volumetric determination of lead. A. TRAVERS AND LU. *Compt. rend.*, **196**, 548–49 (1933).—By boiling a solution containing Pb with an excess of NaClO solution (Javel water) for 15 min., the Pb is converted into insoluble PbO_2. By treating the washed precipitate with KCl and KI solution, the precipitate is changed to one of PbI_2 and an equivalent quantity of I_2 is liberated and can be titrated with $Na_2S_2O_3$ in an aliquot part of the solution. (*C.A.*)

Volumetric determination of uranium in highly ferriferrous ores. W. R. BENNETT. *Jour. Amer. Chem. Soc.*, **56** [2], 277–80 (1934). F.G.H.

A study of Penfield's method for quantitative determination of fluorine. O. KALLAUNER AND K. KURAŠ. *Stavivo*, p. 65 (1933).—The Penfield-Treadwell-Koch method for the determination of fluorine has been modified. Into the vessel where decomposition takes place dehydrated copper uranate is added to ensure complete binding of the water formed during the reaction. A second V-shaped pipe filled with glass balls is used to keep any sulfuric acid from the gas stream. The sensitiveness of the titrimetric determination has been raised by the use of *n*/50 KOH. The titration is performed in an alcoholic medium in the presence of an excess of potassium chloride using methyl-red as indicator. R.B.

Determination of barium and of sulfates. J. C. GIBLIN. *Analyst*, **58**, 752–53 (1933).—Sodium rhodizonate, spotted on to filter paper, was found by Feigl (*Ceram.*

Abs., **13** [4], 103 (1934)) to give a bright red color with Ba salts in acid solution. A volumetric process for estimating Ba and sulfates is worked out. H.H.S.

Thermal expansion of diopside. SHUKUSUKÉ KŌZU AND JUN-ICHI UEDA. *Proc. Imp. Acad.* [Tokyo], **9**, 317–19 (1933).—The linear thermal expansion of crystals of diopside obtained from 4 different sources was measured in the temperature range 20 to 1000° along 3 different directions parallel to *b* and to *c* and perpendicular to (100). The results obtained and the calculated volume thermal expansion are tabulated for every 50° temperature rise. The linear thermal expansion parallel to *b* is in each case about 3 times greater than the other two, which are about equal. The volume thermal expansions range from 1.24 to 1.30% at 500° and from 1.82 to 1.95% at 1000°, compared with the volumes at 20°. Conclusion: Insofar as the present experiments are concerned, the thermal expansion of the diopside varieties is not much affected by variations in the chemical composition. (*C.A.*)

Conductivity of slags in the electric furnace. AXEL WEJNARTH. *Arch. Erzbergbau Erzaufbereit. Metallhüttenw.*, **1**, 191–208 (1931).—In order of decreasing effectiveness, the following constituents lower the electrical conductivity of silicate slags: Al_2O_3, CaO, SiO_2. FeO, and MnO more strongly, raise the conductivity. With rising temperature conductivity increases, the coefficient being smaller with FeO and MnO than with CaO and Al_2O_3 silicates. No definite relation was found between conductivity and viscosity of the systems FeO–SiO_2, FeO–CaO–SiO_2, and FeO–CaO–MnO–Al_2O_3–SiO_2. Conductivity is both metallic and electrolytic; the relative proportion of each depends upon the composition of the slag. Slags from numerous electrothermal processes show great variation in composition. Energy relationships in the slag bath are extremely complicated, partly because of a flaming arc which is influenced by current density and the form of electrode, and partly because of varying temperatures of and near the electrode. Each process requires a specific voltage, charge, depth of bath, and operation. (*C.A.*)

Viscosity of molten slag from acid and basic open-hearth furnaces. T. MATSUKAWA. *Suiyokai-shi*, **8**, 245–56 (1933).—The viscosity of molten slag was measured by a rotating cylinder method. The addition of fluorspar to a basic open-hearth furnace slag makes it more fluid and lowers the melting point about 100° by 1% of F. The viscosity of the slag in which the sum of CaO, MgO, and MnO is about 60% and MnO varies from 0.32 to 13.64% is decreased with the rise of MnO content, and its melting point is lowered. However, the increase of MgO raises the melting point markedly in the slag containing about 36% of CaO–MgO. See also *Ceram. Abs.*, **12** [9], 342 (1933). (*C.A.*)

Theory of the viscosity of liquids. I. E. N. DA C. ANDRADE. *Phil. Mag.*, **17**, 497 (1934).—Previous investigators, basing their concepts as to the viscosity of liquids on gas-viscosity relationships, have been led to conclusions very different from the actual facts observed. The viscosity theories of gases are based on the transfer of molecules from one moving layer to another. A.'s theory for liquids at or near the freezing point postulates the molecular properties of solids rather than gases similar to the Lindeman theory of freezing. Molecules from one moving layer communicate momentum to another layer not by entering this layer but by contacting and joining for a short time at the extreme amplitude of their vibration. A development from this theory leads to the expression for viscosity in the region of the melting temperature in terms of the atomic weight, volume of a gram atom, Avogadro's number, the melting point, and a constant derived from the fundamental frequency. This equation allows the viscosity to be computed and it is shown that the computed values agree with the measured values for six metals to within the limits of the measurements. J.T.L.

Measurement of viscosity by oscillating columns. S. VENKATARAMAN. *Indian Jour. Phys.*, **8**, 25–42 (July 15, 1933).—After reviewing the work done by previous investigators, V. deals with a new method of finding the viscosity of liquids by measuring photographically the damping of their oscillations in a tube. An expression is obtained for the logarithmic decrement in terms of viscosity coefficient and density of the liquid, radius of the tube, and the time of oscillation. The results obtained agree closely with those given in the *International Critical Tables*.

(*Rev. Sci. Instruments*)

Thixotropy in ceramics. S. V. LIPSKIĬ. *Keram. i Steklo*, **9** [10], 24–26 (1933).—L. discusses the theory and researches dealing with thixotropy and thixotropic phenomena in colloidal systems. References are given.

M.V.K.

Thermal expansion of quartz by X-ray measurement. A. H. JAY *Proc. Roy. Soc.* [London], **A142**, 237 (1933); abstracted in *Sprechsaal*, **66** [48], 823 (1933).—The X-ray method of Debye-Scherrer was used to determine the expansion and changes appearing in the crystal lattice of quartz on heating. The powder of a clear, colorless quartz heated from 18 to 770° was investigated, and the lattice dimensions corresponding to every temperature observation were calculated. The transformation point of α- to β-quartz was observed at 579° (according to the optical method it is 575°). With increased temperature, a uniform increase in the lattice occurs; the expansion increases with the approach to the transformation point. It is especially noticeable in the change of axial ratios. While the α-structure changes continuously, a state appears shortly before conversion at which the lattice dimensions show a sudden change characterized by a sudden drop in the values of axial ratios. This decline is ended at the transformation point; the changes of the β-form are comparatively small. M.V.K.

Colorimetric determination of iron. L. SZEGÖR AND B. CASSONI. *Giorn. chim. ind. applicata*, **15** [6], 281–83 (1933).—A method of determining the Fe content colorimetrically with the Pulfrich photometer is described whereby the conditions are maintained in such manner that the absorption is linear to the Fe concentration. M.H.

Influence of iron oxide on vitrification of ceramic clays. OTTO KRAUSE AND HEINRICH TITZE. *Ber. deut. keram. Ges.*, **14** [12], 530–47 (1933).—A study was made of five clays having different iron oxide contents and different colors to determine the change in ceramically important properties and structural changes. The beginning of vitrification was noticeable at about 700°. The progress of vitrification was strongly influenced by the grain size of the clay and by the concentration and degree of division

of the iron oxide. With an oxidizing atmosphere there was also a formation of ferrous-ferric oxide; the ferrous oxide portion caused a dense vitrification as a result of the formation of a thinly liquid flux which had a high solubility for silica. The iron-containing clays studied were shown by X-ray examination to consist of a glassy groundmass and mullite crystals at their highest firing temperature. Examination of the firing trials shows that the iron oxide hydrates give up their water on heating above the monohydrate and hemihydrate stage and change to ferric oxide. Between 600 and 900° there is a linear relation between the optical black content of the firing trials and the content of soluble iron oxide at 700°. These determinations make it possible to base thereon a method for the rapid determination of the iron oxide content. Important conclusions can be drawn from the results obtained. See also *Ceram. Abs.*, **13** [3], 72 (1934). E.J.V.

Isotopy. A. J. G. KAPTEIN. *Chem. Weekblad*, **30** [44], 695–707 (1933).—The nature of isotopes is explained and an exhaustive literary review on this subject is given. 82 references. M.H.

Heat capacities at low temperatures of the alkaline-earth carbonates. C. T. ANDERSON. *Jour. Amer. Chem. Soc.*, **56** [2], 340–42 (1934).—The determination of the heat capacities of coarse and fine calcite, aragonite, strontianite, and witherite is described in detail. Illustrated with curves. F.G.H.

Picrolonic acid as reagent for sodium. Y. VOLMAR AND M. LEBER. *Jour. pharm. chim.*, **17**, 427–31 (1933); *Analyst*, **58**, 782 (1933).—K. salts must be removed by picrate or platino chloride before Na can be tested by the picrolonate method. H.H.S.

BOOKS

Smithsonian Physical Tables. F. E. FOWLE. Smithsonian Institution, Washington, 1933. 8th revised ed. 682 pp. The Smithsonian Physical Tables are so thoroughly appreciated for reference purposes that the appearance of this new edition will be welcomed by all scientific workers. The 7th edition appeared in 1919 and was reprinted three times. To bring the present edition up to date extensive revision has been made and many new tables have been added. (*B.B.N.F.M.R.A.*)

Physico-Chemical Methods. J. REILLY AND W. N. RAE. D. Van Nostrand Co., Inc., New York, 1933. $8.00. Reviewed in *Jour. Amer. Chem. Soc.*, **56** [1], 249–50 (1934); see *Ceram. Abs.*, **13** [3], 74 (1934). F.G.H.

Outline of Physical Chemistry (Grundriss der physikalischen Chemie). A. EUCKEN. 4th ed. Akademische Verlagsgesellschaft m. b. H., Leipzig, 1933. 699 pp. Price 29 Rm. Reviewed in *Jour. Amer. Chem. Soc.*, **56** [1], 254 (1934). F.G.H.

Introduction to Physital Chemistry. A. FINDLAY. Longmans, Green and Co., New York, 1933. 492 pp. Price $3.00. Reviewed in *Jour. Amer. Chem. Soc.*, **56** [1], 254 (1934). F.G.H.

Hydrides of Boron and Silicon. A. STOCK. Cornell Univ. Press, Ithaca, New York, 1933. 250 pp. Price $2.00. Reviewed in *Jour. Amer. Chem. Soc.*, **56** [2], 496 (1934). F.G.H.

Manual of Quantitative Analysis of Minerals (Manual de Chimie Analytique Qualitative Minérale). P. WENGER AND G. GUTZEIT. Georg & Cie., S.A., Librairie de L'Université, Genève, Switzerland, 1933. 496 pp. Reviewed in *Jour. Amer. Chem. Soc.*, **56** [1], 254 (1934). F.G.H.

Methods of Rock Analysis (Gesteinsanalytisches Praktikum). E. DITTLER. **Appendix: Control and Graphical Representation of Rock Analyses.** A. KOHLER. viii + 112 pp. Walter de Gruyter & Co., Berlin and Leipzig, 1933. 4 Rm. Reviewed in *Nature*, **132** [3348], 988 (1933).—The work deals principally with the analysis of silicate rocks. Both the common and the less common elements which may be present are considered. Fluorine and boric acid are included. Determination of total rare earths is included but their separation and individual determination is omitted. Calculations and analytical control form the last part of the work. Distribution of acidic and basic oxides to various mineral constituents is considered. Graphical methods such as Marchet's feldspar triangle are included. J.L.G.

PATENTS

Sodium-sesqui-silicate and method of forming. G. W. MOREY (Philadelphia Quartz Co.). U. S. 1,948,730, Feb. 27, 1934. (1) The method of producing $3Na_2O \cdot 2SiO_2 \cdot 11H_2O$ includes preparing a solution composed of 100 parts of $Na_2SiO_3 \cdot 9H_2O$, 100 parts of NaOH, and 100 parts of water and subsequently effecting crystallization thereof. (2) A method of producing $3Na_2O \cdot SiO_2$ in hydrated crystalline form includes preparing a solution of more alkaline ratio than metasilicate and crystallizing.

Water-resistant alkaline silicate compositions. L. L. LARSON (Grasselli Chemical Co.). U. S. 1,949,914, March 6, 1934. (1) As an adhesive and coating composition an aqueous solution comprises the reaction product obtained by mixing a solution of an alkali metal silicate with a metalammino salt. (2) As an adhesive and coating composition an aqueous solution comprises the reaction product obtained by mixing a solution of sodium silicate of a $Na_2O:SiO_2$ ratio between 1:1 and 1:3.5 with a solution of a copperammino sulfate, the amount of copperammino sulfate used corresponding to 0.5 to 21% $CuSO_4$ based on the sodium silicate solids used.

Production of precipitated titanic oxide. B. LAPORTE, LTD., I. E. WEBER, AND A. N. C. BENNETT. Brit. 405,669, Feb. 21 1934.

General

Drying and firing shrinkage of clays. A. E. R. WESTMAN. *Jour. Can. Ceram. Soc.*, **2**, 24 (1933).—The shrinkage of clays has been the subject of numerous researches. Practically all the data in literature are presented in a form which, while convenient for calculation, makes it difficult to realize the relative importance of the various factors which cause shrinkage. In this lecture some of the data available regarding three typical clays were presented in a form in which the volume changes on drying and firing could be readily visualized. It is concluded that the

shrinkage could be greatly reduced in the plastic process of manufacturing if greater density could be secured in the plastic state. Modern developments which have for their object the production of denser ware in the wet state include (1) dry-pressing under high pressure with optimum water content, (2) casting by pumping slip into molds under high pressure, and (3) permeable pressing in which clay in the plastic state is subjected to mechanical pressure when in contact with water. J.G.P.

Corrosion effects of lubricants on bearing surfaces. C. H. Bierbaum. *Iron Age*, **132** [9], 20–21 (1933).—A scientific article on the beneficiation of lubrication as applied to bearings is presented. A.K.

Symposium on building and plumbing codes. Building codes. George N. Thompson. *Industrial Standardization*, **4** [10], 160–63 (1933). **Plumbing code situation in the United States.** William C. Groeniger. *Ibid.*, pp. 163–68. **National Board of Fire Underwriters' proposed uniform building code.** Clinton T. Bissell. *Ibid.*, pp. 168–70. **Building code developments on the Pacific Coast.** David H. Merrill. *Ibid.*, pp. 171–73. **Uniform building code for municipalities of New England.** Edward W. Roemer. *Ibid.*, pp. 173–75.

Outstanding developments in ceramics in 1932. J. G. Phillips. *Jour. Can. Ceram. Soc.*, **2**, 8 (1933).—A résumé of the technological and industrial developments in ceramics during the year 1932 is given. J.G.P.

Ceramic education: III. Ross C. Purdy. *Bull. Amer. Ceram. Soc.*, **13** [3], 57–58 (1934).

Officers of the American Ceramic Society for 1934–1935. Anon. *Bull. Amer. Ceram. Soc.*, **13** [3], 60–61 (1934).

Report of the Committee on Data of the Refractories Division. George J. Bair. *Bull. Amer. Ceram. Soc.*, **13** [3], 61 (1934).

Report of White Wares Division Standards Committee. R. F. Geller. *Bull. Amer. Ceram. Soc.*, **13** [3], 61 (1934).

North Carolina—The feldspar state. Victor V. Kelsey. *Bull. Amer. Ceram. Soc.*, **13** [3], 64–66 (1934).

Report of Membership Committee of the American Ceramic Society for 1933. P. D. Helser. *Bull. Amer. Ceram. Soc.*, **13** [3], 68 (1934).

Report of the Committee on Ceramic Education. A. V. Bleininger. *Bull. Amer. Ceram. Soc.*, **13** [3], 69–71 (1934).

Collegiate ceramic education: Symposium of replies of ceramic educators, technologists, and engineers on this subject. A. F. Greaves-Walker, Paul E. Cox, Robert J. Montgomery, Walter A. Hull, F. W. Preston, Frank H. Riddle, Hobart M. Kraner, and Ross C. Purdy. *Bull. Amer. Ceram. Soc.*, **13** [3], 71–75 (1934).

Necrology: Leo W. Manion. Anon. *Bull. Amer. Ceram. Soc.*, **13** [3], 76 (1934).

Necrology: Edward Wight Washburn. Anon. *Bull. Amer. Ceram. Soc.*, **13** [3], 78 (1934).

The crystalline form of alumina. G. W. Morey. *Bull. Amer. Ceram. Soc.*, **13** [3], 79–80 (1934).

Ceramic education. Editorial. *Ceram. Ind.*, **22** [3], 137 (1934).—The implications carried in some of the recent published discussions on ceramic education that the curricula of the ceramic schools are far behind the times, that the graduates are not properly equipped to meet the needs of the industry, and that the instruction received is largely irrelevant and of little value are deplored. It is pointed out that one of the fundamental difficulties is within the industry itself. The fine records of the ceramic schools to date are cited, and the comparative newness of ceramic education is pointed out. E.J.V.

Practical education for brickmakers. A. Chmelíček and A. Kučera. *Stavivo*, p. 108 (1933).—An outline of practical courses for the pupils of brickmakers schools. Emphasis is laid on practice in firing kilns. R.B.

The Czechoslovakian Ceramic Society's Committee on Nomenclature. *Zprávy Českoslov. keram. společnosti*, p. 117 (1932). R.B.

Fourth winter course for owners and technical employees of brickworks at Brno. Josef Matějka. *Stavivo*, p. 70 (1933).—The fourth course since 1928 was held at the State Technical University by the Society for Encouragement of the Brick Industry. R.B.

Exposition of Haban and Slovakian ceramics. H. Landsfeld. *Zprávy Českoslov. keram. společnosti*, 1933; *Stavivo*, p. 229 (1933).—The exposition was arranged by the author for this year's annual meeting of the Czechoslovakian Ceramic Society in Slovakia. The exposition gives a survey of the history of Haban and Slovakian ceramics. More than five thousand exhibits from the author's excavations, consisting mainly of potter's equipment and tools were shown. The Habans produced Dutch stove tile as early as 1660. R.B.

Effects of colloidal silica on experimental tuberculosis in guinea pigs. S. L. Cummins and C. Weatherall. *Jour. Hygiene*, **33**, 295 (1933).—Experiments showed that there was a shortening of the survival period in animals given tubercle bacilli along with silica sol as compared with animals infected with tubercle bacilli alone, but the difference was slight and of small significance. The adjuvant action of the silica sol seemed to be local and transitory, and any tendency to a more rapid dissemination of bacilli appeared to be neutralized by the local fibrosis following the introduction of silica sol into the tissues. The findings agree with the fact that the tuberculosis death rate in industries involving exposure to silica dust is high in middle age after many years of dust inhalation, and not in the early years of exposure as should be the case if silica determined an early generalization of tuberculosis infection. (*T.C.S.E.*)

Silicosis compensation. I. H. D. Keiser. *Eng. Mining Jour.*, **135** [1], 34–36 (1934).—K. discusses the legal or compensation features of silicosis and other pneumoconioses (the inclusive medical term for diseases of the lungs caused by dust). The laws of various countries on this subject are noted, and the interpretations which have been put on the compensation laws of different states in this respect are discussed. Illustrated by X-ray photographs. J.L.G.

Silica content of lungs. A. F. Sladden. *Lancet*, **225**, 123–25 (1933); *Analyst*, **58**, 775–76 (1933).—Analyses suggest that 1.6% SiO_2 in lungs cause so much damage to the pulmonary drainage system that exposure to further silica endangers life. H.H.S.

Silicosis in potters' shops. F. H. Hand. *Times Eng. Supp.*, **33**, 288 (1933).—The ideal floor is one which would prevent the accumulation of clay scraps, etc., on the walking surface. A "grid" floor is recommended. H.H.S.

Silicotic lungs: the minerals they contain. W. R. JONES. *Jour. Hygiene*, **33** [3], 307 (1933); *Nature*, **132** [3346], 941 (1933); *Chem. Trade Jour.* [London], **94** [2436], 58 (1934); for abstract see *Ceram. Abs.*, **13** [4], 105 (1934).

Protection of workers exposed to chromium and its compounds. METROPOLITAN LIFE INSURANCE CO. *Foundry*, **62** [1], 62 (1934). F.G.H.

Distilleries hold many uses for clay products. ANON. *Brick Clay Rec.*, **84** [2], 60–62 (1934).—Illustrated. E.J.V.

BOOKLET

Silicosis. INDUSTRIAL HEALTH SECTION, METROPOLITAN LIFE INSURANCE COMPANY. 32 pp. The booklet was prepared for the information of plant superintendents and foremen in departments where silica dust is present. It suggests aids in controlling dusty processes. A limited number of copies are available for distribution. Requests may be addressed to the Industrial Health Section, Metropolitan Life Insurance Co., 1 Madison Ave., New York, N. Y. The Welfare Division of the Metropolitan Life Insurance Company is prepared to furnish a detailed bibliography on silicosis. Illustrated.

PATENT

Treatment of mineral substances. FRIEDRICH C. KRÜGER AND KARL RETTER. Ger. 582,369, Aug. 14, 1933. To remove metal-compound impurities such as Fe_2O_3 from minerals such as clay, quartz, and phosphates, or to recover metal compounds from minerals, the latter are subjected to the action of high- or low-frequency induction current in the presence of an acid compound capable of dissolving the metal compounds or converting them into a volatile form. (*C.A.*)